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BASE STATION TRANSMISSION POWER CONTROL SYSTEM

Publication number:	JP9074378 (A)
Publication date:	1997-03-18
Inventor(s):	TAKAI KENICHI; WATANABE KYOJI +
Applicant(s):	NEC CORP +
Classification:	
- international:	***H04B7/005; H04B7/26; H04W52/40;*** (IPC1-7): H04B7/26; H04Q7/22; H04Q7/28
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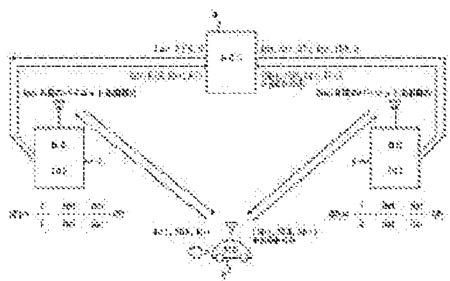
Abstract of **JP 9074378 (A)**

PROBLEM TO BE SOLVED: To reduce down channel interference by estimating the propagation characteristics of a down channel line between a base station and a mobile station based on the reception power of a pilot channel and deciding the transmission power of a traffic channel. SOLUTION: This system is mainly composed of the base stations (BSes) 1 and 2, the mobile station(MS) 3 and a base station monitoring device (BSC) 4 for performing monitoring as the host station of them.; Then, with the transmission power of the pilot channel of the respective base stations 1 and 2 stored in the host station beforehand, the reception power in the mobile station 3 of the pilot channel of the respective base stations 1 and 2 reported from the mobile station 3, the error rate of the traffic channel and the transmission power of the traffic channel reported from the base stations 1 and 2 as parameters, the transmission power of the traffic channel of the base stations 1 and 2 is decided. In such a manner, the reception power of the pilot channel from the respective base stations 1 and 2 is measured in the mobile station 3 and the propagation characteristics of the mobile station 3 and the respective base stations 1 and 2 are calculated.



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特開平9－74378

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ＨＯ４Ｂ　7/26	１０２		ＨＯ４Ｂ　7/26	１０２	
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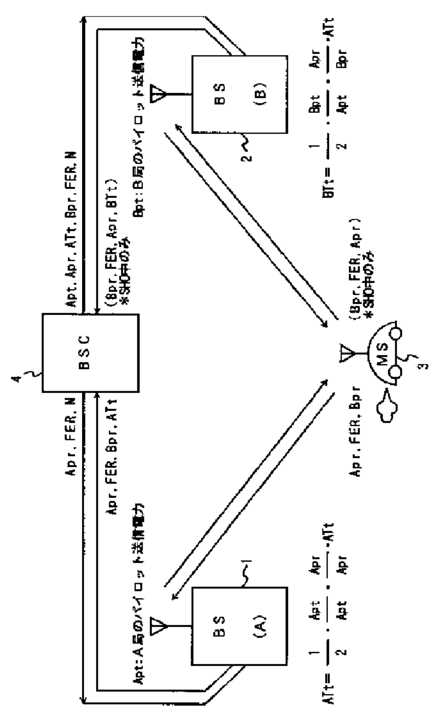
(54)【発明の名称】　基地局送信電力制御方式

(57)【要約】
【課題】　符号分割多元接続方式を利用したセルラー移動通信システムにおいて、ソフトハンドオフの起動により生じる下り干渉を最小限に抑え、セル境界付近に存在する移動局における下りトラフィックチャネルの受信電界レベルの低下を防ぐ。
【解決手段】　移動局がパイロットチャネルの受信電力を基地局に報告し、基地局は報告された情報とパイロットチャネルおよびトラフィックチャネルの送信電力からソフトハンドオフ時の最適なトラフィックチャネルの送信電力を計算する。



【特許請求の範囲】

【請求項１】　符号分割多元接続（ＣＤＭＡ）方式を利用したセルラー移動通信システムにおいて、移動局が複数の基地局と同時に通信を行うソフトハンドオフに関し、上記移動局における上記基地局からのパイロットチャネル（基地局が常時送信している制御チャネル）の受信電力に応じて、上記基地局が上記移動局へ送信する下り（基地局→移動局）トラフィックチャネル（通信チャネル）の初期送信電力および通信中の送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項２】　上記請求項１に記載の基地局送信電力制御方式において、ソフトハンドオフを行う上記移動局における上記各基地局からの下りトラフィックチャネルの受信電力が全て等しくなるように、かつ上記移動局における上記基地局すべてからのトラフィックチャネルの合成受信電力が一定の値となるように上記基地局からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項３】　上記請求項２に記載の基地局送信電力方式において、上記移動局における上記基地局からの下りトラフィックチャネルの合成受信電力を一定に保つ代わりに、上記移動局における上記下りトラフィックチャネルのエラーレートが所要の閾値を満足するように上記各基地局からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項４】　上記請求項１に記載の基地局送信電力制御方式において、上記移動局における上記各基地局からの下りトラフィックチャネルの受信電力の比と上記移動局において受信されるパイロットチャネルの受信電力の比が等しくなるように、かつ上記移動局における上記基地局からの下りトラフィックチャネルの合成受信電力が一定の値となるように上記基地局からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項５】　上記請求項４に記載の基地局送信電力制御方式において、上記移動局における上記基地局からの下りトラフィックチャネルの合成受信電力を一定に保つ代わりに、上記移動局における上記下りトラフィックチャネルのエラーレートが所要の閾値を満足するように上記各基地局からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項６】　上記請求項１に記載の基地局送信電力制御方式において、上記移動局における上記各基地局からのパイロットチャネルの受信電力の比と各基地局の下りトラフィックチャネルの送信電力の比が等しくなるように、かつ上記移動局における上記基地局からの下りトラフィックチャネルの合成受信電力が一定の値となるように上記基地局からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【請求項７】　上記請求項６に記載の基地局送信電力方式において、上記移動局における上記基地局からの下りトラフィックチャネルの合成受信電力を一定に保つ代わりに、上記移動局における上記下りトラフィックチャネルのエラーレートが所要の閾値を満足するように上記基地局各々からの下りトラフィックチャネルの初期送信電力および通信中送信電力を制御することを特徴とする基地局送信電力制御方式。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本願発明は、符号分割多元接続（ＣＤＭＡ）方式を利用した無線通信システム、特にセルラー移動通信システムにおいて、ソフトハンドオフを実行する際の基地局からの下りトラフィックチャネルにおける初期送信電力および通信中送信電力の制御方式に関するものである。

【０００２】

【従来の技術】符号分割多元接続（ＣＤＭＡ）方式を利用した無線通信システム、特にセルラー移動通信システムにおいては、限られた周波数帯域を用いて１つのエリア（セル）内にどれだけ多くの回線容量をもつことができるかという点がシステム設計の上で重要となる。符号分割多元接続方式においては、複数のユーザーが同一の周波数上で通信を行い、各ユーザーに割り当てられた符号間の直交性により各ユーザー通信間の干渉の低減が保証されている。また、符号間の直交性を充分に引き出すためには、受信点における複数受信波のレベルをすべて同一にすることが望まれる。このためセルラー移動通信システムにおいては、特に同一の基地局エリア内に存在する移動局間での同期確保が不可能な上り（移動局→基地局）通信に関しては、各移動局からの受信波が基地局において全て同レベルで受信されるように移動局での厳密な送信電力制御が行われるのが一般的である。

【０００３】このため、従来の技術においては、上り（移動局→基地局）トラフィックチャネルの送信電力制御方式に関する技術は複数提案がなされており、特開昭６２－９２５２６号公報においては上りトラフィックチャネルを受信側でレベル制御を行うという提案がなされている。また、特開平７－９５１５１号公報においては下り（基地局→移動局）トラフィックチャネルの初期送信電力の決定方法については技術提案がなされているが、基地局と移動局が通信中のトラフィックチャネルの送信電力制御方法については提案がなされておらず、また符号分割多元接続（ＣＤＭＡ）方式に特有のソフトハンドオフ（移動局が複数の基地局と同時に通信を行う）の起動に関する下りトラフィックチャネルの送信電力制御方法に関しては提案がなされていない。

【０００４】

【発明が解決しようとする課題】このような従来の技術の問題点は、移動局がエリア内を移動してセル境界に達したときにソフトハンドオフを起動すると、新たに通信を行う基地局から送信されるトラフィックチャネルによりその基地局セル内での下り干渉が増加するという点である。これは、基地局が送信するトラフィックチャネルの初期送信電力が固定的に設定されており、移動局と基地局間の伝送特性を考慮して制御されないためである。

【０００５】さらに、従来の技術ではソフトハンドオフを実行中の移動局に対して過剰な電力のトラフィックチャネルが送信される可能性があることに加え、その過剰電力により同一セル内またはそのセル付近に存在する他の移動局に対する下り干渉が増加するという問題がある。この理由も、上記の問題点と同様にソフトハンドオフ中に基地局が送信するトラフィックチャネルの送信電力が固定的に設定されており、移動局の動きに追従して制御がなされないためである。

【０００６】また、従来の技術では移動局がセル境界付近へ移動した際に、ソフトハンドオフを起動するか否かによらず、移動局における下りトラフィックチャネルの受信電力が低下し、それにより下り通信のエラーレートが悪化するという問題もある。この原因となるところも上記の問題点と同様に下りトラフィックチャネルの送信電力が固定的に決定されており、移動局の動きに追従して制御がなされないためである。

【０００７】本願発明の基地局送信電力制御方式は、移動局の位置する場所、または通信状態（ソフトハンドオフ中か否か）によらず、所要の通信品質を満足するために必要な最小限の送信電力で下り（基地局→移動局）トラフィックチャネルを送信するように制御することにより、送信機の消費電力を低減するほか、同一セルまたはセル付近に存在する他の移動局に対する下り干渉を低減することにより、システムの回線容量を最大限まで引き出し、結果として装置の小型化および周波数有効利用を目的とする。

【０００８】

【課題を解決するための手段】本発明の基地局送信電力制御方式は、移動局における基地局からのパイロットチャネルの受信電力に基づいて、基地局と移動局間の下り回線の伝搬特性を推定し、移動局がソフトハンドオフを起動する際、または起動中に基地局が送信するトラフィックチャネルの送信電力を決定する。

【０００９】具体的には、図１、図２、図３に示すように、上位局があらかじめ記憶している各基地局のパイロットチャネルの送信電力と移動局から報告される各基地局のパイロットチャネルの移動局における受信電力とトラフィックチャネルのエラーレート、さらに基地局から報告されるトラフィックチャネルの送信電力をパラメータとして、基地局のトラフィックチャネルの送信電力を決定する。また、図５に示す移動局の送受信ブロックにおいて、基地局からのパイロットチャネルを受信してその電力を測定するためのミキサ２４、ローカル周波数発振部２１、パイロットチャネル用ＰＮ符号生成部２３、ミキサ２５、フィルタ２６、包絡線検波部２７、フィルタ２８、そして受信したパイロットチャネルの測定結果を基地局へ送信するための情報生成部３３、振幅情報生成部３２、送信用ＰＮ符号生成部３５、ミキサ３１、送信データ変調用のローカル周波数発振部３４、ミキサ３０、送信増幅部２９が主な構成要素となる。また、図４に示す基地局の送信ブロックにおいては、情報生成部５、振幅情報生成部６、送信用ＰＮ符号生成部６、ミキサ７、ローカル周波数発振部１０、ミキサ８、送信増幅部１１が主な構成要素である。

【００１０】さらに詳細には、本発明による基地局送信電力制御方式は大きく分けて３つに分けることが出来る。１つは、移動局において受信される各基地局のトラフィックチャネルの受信電力が全て等しくなるように、かつ移動局におけるトラフィックチャネルの合成受信電力が一定となるように、各基地局のトラフィックチャネルの送信電力を制御する方法。２つは目は、移動局において受信される各基地局のトラフィックチャネルの受信電力の比が各基地局からのパイロットチャネルの受信電力の比と等しくなるように、かつ移動局におけるトラフィックチャネルの合成受信電力が一定となるように、各基地局のトラフィックチャネルの送信電力を制御する方法。そして３つ目は、各基地局のトラフィックチャネルの送信電力の比が移動局において受信される各基地局のパイロットチャネルの受信電力の比と等しくなるように、かつ移動局におけるトラフィックチャネルの合成受信電力が一定となるように、各基地局のトラフィックチャネルの送信電力を制御する方法である。

【００１１】以上の構成により、移動局のパイロットチャネル受信部によりダウンコンバートされ、逆拡散されて取り出されたパイロットチャネルは、包絡線検波部においてその受信レベルが検出される。検出された受信電力は移動局の送信ブロックの情報生成部に送られ、基地局に報告するためにデータをして重畳される。送信データに重畳されたパイロットチャネルの受信電力情報は送信用ＰＮ符号生成部で生成されたＰＮ符号により拡散され、アップコンバートされて基地局へ送信される。基地局において受信された移動局からの情報はダウンコンバートされ、逆拡散された後、上位局にいったん送られる。上位局でデコードされた受信電力の情報は再度基地局へ折り返され、基地局内部の演算回路に入力され、そこで下りトラフィックチャネルの送信電力が計算される。計算結果は、送信ブロックの振幅情報生成部に送られ、トラフィックチャネルの送信電力が設定される。

【００１２】こうして、移動局におけるパイロットチャネルの受信電力を基地局に折り返すことにより、基地局

において基地局と移動局間の伝搬特性を推定することができ、最適な下りトラフィックチャネルの送信電力を求めることができる。

【００１３】

【発明の実施の形態】次に本願発明について図面を参照して説明する。

【００１４】図１は、本願発明の基地局送信電力制御方式を実現するセルラー移動通信システムの基本構成を示すブロック図である。本システムは、主として基地局（ＢＳ）１，２、移動局（ＭＳ）３およびそれらの上位局として監視を行う基地局監視装置（ＢＳＣ）４からなる。

【００１５】さらに、図１で示す基地局内部に含まれる送信部の基本的ブロックの一実施例を図４に示す。本送信ブロックは、送信する情報を生成する情報生成部５、送信出力の振幅情報を生成する振幅情報生成部６、ＰＮ符号生成部９、生成した情報とＰＮ符号を重畳するミキサ７、ローカル周波数発振部１０、ＰＮ拡散した情報をローカル周波数で変調をかけるミキサ８、送信変調波を所要出力まで増幅する増幅部１１、そしてアンテナ１２から構成される。

【００１６】さらに、図１で示す移動局内部に含まれる送受信部の基本的ブロックの一実施例を図５に示す。本送受信ブロックのうち受信ブロックは、送受信アンテナ１３、アンテナ共用部１４、信号分配部１５、受信波をダウンコンバートするミキサ１６、ダウンコンバートした受信波をＰＮ逆拡散するためのミキサ１７、受信増幅部１８、フィルタ１９、情報復調部２０、ローカル周波数発振部２１、受信波復調用ＰＮ符号生成部２２、パイロットチャネル用ＰＮ符号生成部２３、パイロットチャネルをダウンコンバートするためのミキサ２４、パイロットチャネルを逆拡散するためのミキサ２５、フィルタ２６、パイロットチャネルの受信電力を検出する包絡線検波部２７、フィルタ２８により構成される。また、本送受信ブロックのうち送信ブロックは送信情報を生成する情報生成部３３、送信出力を決定する振幅情報生成部３２、送信用ＰＮ符号生成部３５、送信データを拡散するためのミキサ３１、ローカル周波数発振部３４、送信データを変調するためのミキサ３０、送信増幅部２９から構成される。

【００１７】次に本願発明の動作について説明する。

【００１８】まず初めに本願発明の請求項２および３に記載の実施例の動作について、図１、図６そして図７を用いて説明する。

【００１９】図１において、移動局（ＭＳ）が基地局Ａ（ＢＳ（Ａ））のセルに存在し、基地局Ａとのみ通信し、所要の通信品質が得られているものと仮定する。このとき、基地局Ａのパイロットチャネルの送信電力をＡｐｔ、トラフィックチャネルの送信電力をＡＴｔ、移動局における基地局Ａのパイロットチャネルの受信電力をＡｐｒ、トラフィックチャネルの受信電力をＡＴｒ、トラフィックチャネルのエラーレートをＦＥＲとする。移動局が基地局Ｂへ向かって移動し、基地局Ｂとソフトハンドオフを起動する瞬間を考える。このとき移動局における基地局Ｂからのパイロットチャネルの受信電力をＢｐｒとする。

【００２０】移動局は基地局Ａとの通信の中で、移動局におけるＡｐｒ，ＦＥＲ，Ｂｐｒを基地局Ａに報告している。移動局によりコーディングされ報告された情報は基地局Ａを通過して上位局（ＢＳＣ）へ送られるが、この情報とともに基地局Ａは自局のトラフィックチャネルの送信電力を上位局へ報告する。報告を受けた上位局は、移動局からの情報をデコードして、さらに移動局がソフトハンドオフを起動することにより通信する全基地局の数（Ｎ）を求めて基地局Ａに折り返すと同時に、これと同じ内容に基地局Ａからの情報（トラフィックチャネルの送信電力ＡＴｔ）を付加して基地局Ｂへ送る。

【００２１】基地局Ａおよび基地局Ｂでは、計算式に従いそれぞれのトラフィックチャネルの初期送信電力を決定する。図１に示すＡＴｔを求める計算式（図６、図７の計算式も同様）によると、各基地局からのトラフィックチャネルは、移動局においてどちらも等しい電力で受信されるように、かつ２つの基地局からのトラフィックチャネルの合成受信電力は、移動局がソフトハンドオフを行う前に基地局Ａからのみ受信していたトラフィックチャネルの受信電力と等しくなるようにそれぞれの基地局のトラフィックチャネルの送信電力が決定される。

【００２２】さらに、移動局がソフトハンドオフを起動した後も移動し続け、移動局と各基地局との間の伝搬特性が変化した場合を考える。

【００２３】移動局で受信されたパイロットチャネルの受信電力とトラフィックチャネルのエラーレートは基地局Ａおよび基地局Ｂを経由して同じ内容が上位局へ報告される。しかしこの点を除いては、以下のフローは上記のソフトハンドオフ起動時と全く同様である。したがって、移動局が基地局間を移動しても常に移動局においては基地局Ａと基地局Ｂのトラフィックチャネルは等しい受信電力で受信され、かつそれらの合成受信電力は常に一定に保たれる。

【００２４】また、上記では移動局におけるトラフィックチャネルの合成受信電力が一定になるとしたが、それぞれの基地局が前記の計算式に従い送信電力を決定した後で、移動局から報告されるトラフィックチャネルのエラーレートが所要の値を満足するように、基地局Ａと基地局Ｂとが同比率ずつトラフィックチャネルの送信電力を増減してもよい。

【００２５】次に本願発明の請求項４および請求項５に記載の実施例の動作について、図２、図８そして図９を用いて説明する。

【００２６】図２において、移動局（ＭＳ）が基地局Ａ

（ＢＳ（Ａ））のセルに存在し、基地局Ａとのみ通信し、所要の通信品質が得られているものと仮定する。このとき、基地局Ａのパイロットチャネルの送信電力をＡｐｔ、トラフィックチャネルの送信電力をＡＴｔ、移動局における基地局Ａのパイロットチャネルの受信電力をＡｐｒ、トラフィックチャネルの受信電力をＡＴｒ、トラフィックチャネルのエラーレートをＦＥＲとする。移動局が基地局Ｂへ向かって移動し、基地局Ｂとソフトハンドオフを起動する瞬間を考える。このとき移動局における基地局Ｂからのパイロットチャネルの受信電力をＢｐｒとする。

【００２７】移動局は基地局Ａとの通信の中で、移動局におけるＡｐｒ，ＦＥＲ，Ｂｐｒを基地局Ａに報告している。移動局によりコーディングされ報告された情報は基地局Ａを通過して上位局（ＢＳＣ）へ送られるが、この情報とともに基地局Ａは自局トラフィックチャネルの送信電力を上位局へ報告する。報告を受けた上位局は、移動局からの情報をデコードして基地局Ａに折り返すと同時に、これと同じ内容に基地局Ａからの情報（基地局Ａのトラフィックチャネルの送信電力）を付加して基地局Ｂへ送る。基地局Ａおよび基地局Ｂでは、計算式に従いそれぞれのトラフィックチャネルの初期送信電力を決定する。図２に示すＡＴｔを求める計算式（図８、図９の計算式も全て同じ）によると、各基地局からのトラフィックチャネルは、移動局において受信されているそれぞれの基地局のパイロットチャネルの受信電力の比と等しい比で受信されるように、かつ２つの基地局からのトラフィックチャネルの合成受信電力は、移動局がソフトハンドオフを行う前に基地局Ａからのみ受信していたトラフィックチャネルの受信電力と等しくなるようにそれぞれの基地局のトラフィックチャネルの送信電力が決定される。

【００２８】さらに、移動局がソフトハンドオフを起動した後も移動し続け、移動局と各基地局との間の伝搬特性が変化した場合を考える。

【００２９】移動局で受信されたパイロットチャネルの受信電力とトラフィックチャネルのエラーレートは基地局Ａおよび基地局Ｂを経由して同じ内容が上位局へ報告される。しかしこの点を除いては、以下のフローは上記のソフトハンドオフ起動時と全く同様である。したがって、移動局が基地局間を移動しても常に移動局における基地局Ａと基地局Ｂのトラフィックチャネルの受信電力の比はそれぞれの基地局のパイロットチャネルの受信電力の比と等しく、かつそれらの合成受信電力は常に一定に保たれる。

【００３０】また、上記では移動局におけるトラフィックチャネルの合成受信電力が一定になるとしてが、それぞれの基地局が式に従い送信電力を決定した後で、移動局から報告されるトラフィックチャネルのエラーレートが所要の値を満足するように、基地局Ａと基地局Ｂとが同比率ずつトラフィックチャネルの送信電力を増減してもよい。

【００３１】次に本願発明の請求項６および請求項７に記載の実施例の動作について、図３、図１０そして図１１を用いて説明する。

【００３２】図３において、移動局（ＭＳ）が基地局Ａ（ＢＳ（Ａ））のセルに存在し、基地局Ａとのみ通信し、所要の通信品質が得られているものと仮定する。このとき、基地局Ａのパイロットチャネルの送信電力をＡｐｔ、トラフィックチャネルの送信電力をＡＴｔ、移動局における基地局Ａのパイロットチャネルの受信電力をＡｐｒ、トラフィックチャネルの受信電力をＡＴｒ、トラフィックチャネルのエラーレートをＦＥＲとする。移動局が基地局Ｂへ向かって移動し、基地局Ｂとソフトハンドオフを起動する瞬間を考える。このとき移動局における基地局Ｂからのパイロットチャネルの受信電力をＢｐｒとする。

【００３３】移動局は基地局Ａとの通信の中で、移動局におけるＡｐｒ，ＦＥＲ，Ｂｐｒを基地局Ａに報告している。移動局によりコーディングされ報告された情報は基地局Ａを通過して上位局（ＢＳＣ）へ送られるが、この情報とともに基地局Ａは自局トラフィックチャネルの送信電力を上位局へ報告する。報告を受けた上位局は、移動局からの情報をデコードして、さらに上位局があらかじめ記憶している基地局Ｂのパイロットチャネルの送信電力Ｂｐｔを付加して基地局Ａに折り返すと同時に、移動局からの情報と基地局Ａからの情報（基地局Ａのトラフィックチャネルの送信電力）、さらにあらかじめ上位局が記憶している基地局Ａのパイロットチャネルの送信電力Ａｐｔを付加して基地局Ｂへ送る。基地局Ａおよび基地局Ｂでは、計算式に従いそれぞれのトラフィックチャネルの初期送信電力を決定する。図３に示すＡＴｔを求める計算式（図１０、図１１の計算式も全て同じ）によると、各基地局からのトラフィックチャネルの送信電力は、移動局において受信されているそれぞれの基地局のパイロットチャネルの受信電力の比と等しい比で送信されるように、かつ２つの基地局からのトラフィックチャネルの合成受信電力は、移動局がソフトハンドオフを行う前に基地局Ａからのみ受信していたトラフィックチャネルの受信電力と等しくなるようにそれぞれの基地局のトラフィックチャネルの送信電力が決定される。

【００３４】さらに、移動局がソフトハンドオフを起動した後も移動し続け、移動局と各基地局との間の伝搬特性が変化した場合を考える。移動局で受信されたパイロットチャネルの受信電力とトラフィックチャネルのエラーレートは基地局Ａおよび基地局Ｂを経由して同じ内容が上位局へ報告される。しかしこの点を除いては、以下のフローは上記のソフトハンドオフ起動時と全く同様である。したがって、移動局が基地局間を移動しても常に基地局Ａと基地局Ｂのトラフィックチャネルの送信電力

の比は、移動局においては受信されるそれぞれの基地局のパイロットチャネルの受信電力の比と等しく、かつそれらの合成受信電力は常に一定に保たれる。

【００３５】また、上記では移動局におけるトラフィックチャネルの合成受信電力が一定になるとしてが、それぞれの基地局が式に従い送信電力を決定した後でも、移動局から報告されるトラフィックチャネルのエラーレートが所要の値を満足するように、基地局Ａと基地局Ｂとが同比率ずつトラフィックチャネルの送信電力を増減してもよい。

【００３６】

【発明の効果】以上説明したように本願発明によれば、移動局がソフトハンドオフを起動する際、またはソフトハンドオフを起動中に、上記移動局に送信される下りトラフィックチャネルにより生じる干渉を最小限に抑え、かつ上記移動局における上記各基地局からの下りトラフィックチャネルの受信ダイバーシチゲインを最大にすることができる。それは、上記移動局において各基地局からのパイロットチャネルの受信電力を測定し上記移動局と上記各基地局との伝搬特性を計算することにより、上記移動局における上記各基地局からの下りトラフィックチャネルの受信電力が全て等しくなるように、かつ上記移動局における上記下りトラフィックチャネル合成受信電力が一定の値となるように上記各基地局の下りトラフィックチャネルの送信電力を制御するからである。

【００３７】また、本願発明によれば、移動局がソフトハンドオフを起動する際、またはソフトハンドオフを起動中に、上記移動局に送信される下りトラフィックチャネルにより生じる干渉を、図１３に示すように、最小限に抑え、かつ移動局が通信している各セルの大きさに応じて均等に干渉を分配することができる。それは、上記移動局における上記各基地局からトラフィックチャネルの受信電力の比がパイロットチャネルの受信電力の比と等しくなるように、かつ上記移動局における上記基地局からのトラフィックチャネルの合成受信電力が一定の値となるように上記各基地局の下りトラフィックチャネルの送信電力を制御するからである。

【００３８】また、本願発明によれば、移動局ガソフトハンドオフを起動する際、またはソフトハンドオフを起動中に、上記移動局に送信される下りトラフィックチャネルにより生じる干渉を最小限に抑え、かつ移動局が通信する各基地局の下りトラフィックチャネルの送信電力は上記移動局と上記基地局との間の伝搬損失に応じて、伝搬損失が少ない方の基地局を強く、伝搬損失の多い方の基地局からは弱く送信することにより、伝搬損失の大きいセルへの過剰な下り干渉が発生するのを防ぐことができる。それは、上記移動局において各基地局からのパイロットチャネルの受信電力を測定し上記移動局と上記各基地局との伝送特性を計算することにより、上記基地局からのトラフィックチャネルの下り送信電力の比と上記移動局において受信されるパイロットチャネルの受信電力の比が等しくなるように、かつ上記移動局における上記下りトラフィックチャネル合成受信電力が一定の値となるように上記各基地局の下りトラフィックチャネルの送信電力を制御するからである。（図１３参照）

【００３９】さらに本願発明によれば、移動局がセル境界付近へ移動した際に、ソフトハンドオフを行うか否かによらず基地局からの下りトラフィックチャネルの受信電力の落ち込みを防ぎ、エラーレートが悪化することを防ぐことができる。本発明で提案する下りトラフィックチャネルの送信電力制御を行わない場合には、図１２に示すようにセルの境界付近において移動局における下りトラフィックチャネルの受信レベルが悪化し、例えば図１２の場合にはセル境界付近でＥｂ／Ｎ０が５ｄＢを割ると、下りトラフィックチャネルのエラーレートが０．７％を上回るようになる。それは、上記移動局におけるトラフィックチャネルの合成受信電力が常に一定の値となるように、またはトラフィックチャネルのエラーレートが所要の値を満足するように基地局のトラフィックチャネルの送信電力を制御するからである。

【図面の簡単な説明】

【図１】本発明の請求項２、および請求項３に記載の基地局送信電力制御方式の一実施例を示した図である。

【図２】本発明の請求項４、および請求項５に記載の基地局送信電力制御方式の一実施例を示した図である。

【図３】本発明の請求項６、および請求項７に記載の基地局送信電力制御方式の一実施例を示した図である。

【図４】本発明の実施例をして示した図１、図２、図３の基地局において用いられる送信部の基本的なブロックの一例を示した図である。

【図５】本発明の実施例をして示した図１、図２、図３の移動局において用いられる送受信部の基本的なブロックの一例を示した図である。

【図６】本発明の請求項２および請求項３に記載の基地局送信電力制御方式のソフトハンドオフ起動時の実施フローを示した図である。

【図７】本発明の請求項２および請求項３に記載の基地局送信電力制御方式のソフトハンドオフ中の実施フローを示した図である。

【図８】本発明の請求項４および請求項５に記載の基地局送信電力制御方式のソフトハンドオフ起動時の実施フローを示した図である。

【図９】本発明の請求項４および請求項５に記載の基地局送信電力制御方式のソフトハンドオフ中の実施フローを示した図である。

【図１０】本発明の請求項６および請求項７に記載の基地局送信電力制御方式のソフトハンドオフ起動時の実施フローを示した図である。

【図１１】本発明の請求項６および請求項７に記載の基地局送信電力制御方式のソフトハンドオフ中の実施フロ

ーを示した図である。

【図１２】本発明の基地局送信電力方式を用いない場合、移動局が唯１つの基地局とのみ通信することを仮定して、基地局から移動局までの距離によって下りトラフィックチャネルの受信電力（Ｅｂ／Ｎ０）がどのように変化するかを計算した結果を示したグラフである。本計算は、以下の仮定に基づいている。

・セル構成：着目する２基地局の回りを８つの干渉局が取り囲む

・基地局間距離：６ｋｍ

・減衰係数：α＝３．５

・遅延特性：等電力２波モデル

・１つのトラフィックチャネルの送信電力が全体に占める割合：２．５％

【図１３】本発明の基地局送信電力方式を用いた場合、移動局と基地局との距離に応じて基地局の中の１つのトラフィックチャネルの送信電力が全体に占める割合がどのように変化するかを計算した結果を示したグラフである。計算においては、以下の仮定に基づいている。

・ソフトハンドオフの起動範囲：基地局Ａからの距離が２．４ｋｍ～３．６ｋｍの範囲

・Ｅｂ／Ｎ０の値：ソフトハンドオフ起動前の２．４ｋｍ地点におけるＥｂ／Ｎ０（５．２５ｄＢ）を保つ

【符号の説明】

１　移動局が最初に通信している基地局Ａ

２　移動局が基地局Ａから移動し、ソフトハンドオフを起動しようとする基地局Ｂ

３　移動局。基地局Ａのセルから基地局Ｂのセルへ向かって移動すると仮定する。初め、移動局は基地局Ａとのみ通信し、次第に基地局Ｂに近づくとともに基地局Ｂとも通信をし始め、ソフトハンドオフ状態となる。

４　上位局。基地局Ａおよび基地局Ｂ、さらに両基地＊局を通して移動局を監視制御すると同時に、両基地局間の情報を中継する役割を果たす。

５　基地局送信ブロックの情報生成部

６　基地局送信ブロックの振幅情報生成部

７　基地局送信ブロックのミキサ

８　基地局送信ブロックのミキサ

９　基地局送信ブロックのＰＮ符号生成部

１０　基地局送信ブロックのローカル周波数発振部

１１　基地局送信ブロックの増幅部

１２　基地局アンテナ

１３　移動局アンテナ

１４　移動局送受信ブロックのフィルタ部

１５　移動局送受信ブロックの分配部

１６　移動局送受信ブロックのミキサ

１７　移動局送受信ブロックのミキサ

１８　移動局送受信ブロックの受信増幅部

１９　移動局送受信ブロックのフィルタ部

２０　移動局送受信ブロックの復調部

２１　移動局送受信ブロックのローカル周波数発振部

２２　移動局送受信ブロックのＰＮ符号生成部

２３　移動局送受信ブロックのＰＮ符号生成部

２４　移動局送受信ブロックのミキサ

２５　移動局送受信ブロックのミキサ

２６　移動局送受信ブロックのフィルタ部

２７　移動局送受信ブロックの包絡線検波部

２８　移動局送受信ブロックのフィルタ部

２９　移動局送受信ブロックの送信増幅部

３０　移動局送受信ブロックのミキサ

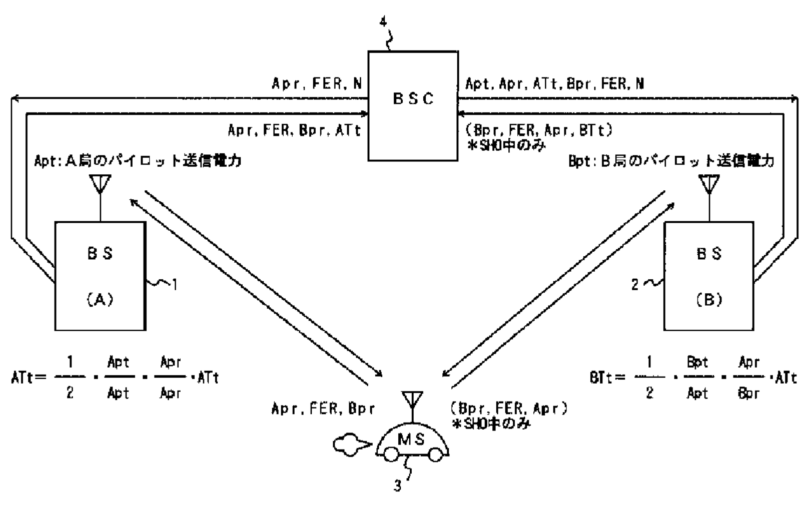
３１　移動局送受信ブロックのミキサ

３２　移動局送受信ブロックの振幅情報生成部

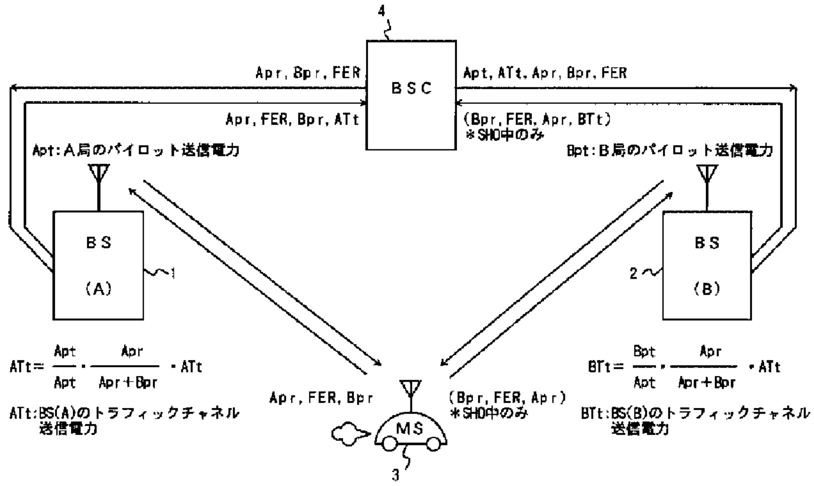
３３　移動局送受信ブロックの情報生成部

３４　移動局送受信ブロックのＰＮ符号生成部

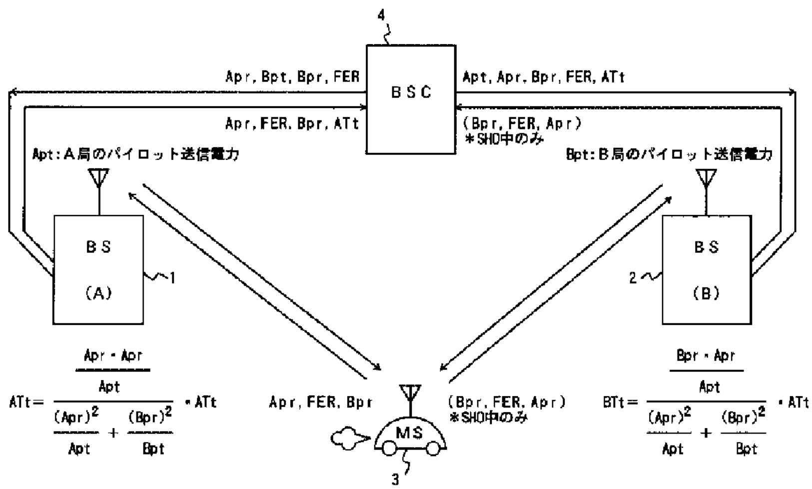
【図１】



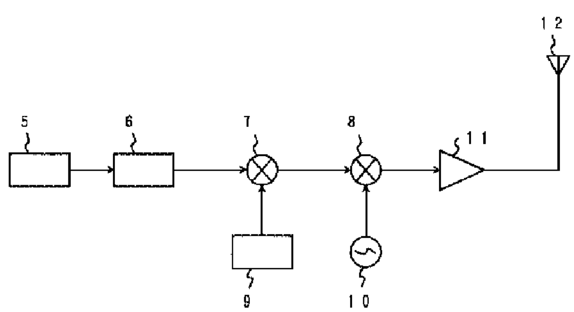
【図2】


BSC
4
Apr, Bpr, FER
Apt, ATt, Apr, Bpr, FER
Apr, FER, Bpr, ATt
(Bpr, FER, Apr, BTt)
＊SHO中のみ
Apt：A局のパイロット送信電力
Bpt：B局のパイロット送信電力
BS (A)
1
BS (B)
2
ATt＝Apt/Apt・Apr/(Apr＋Bpr)・ATt
BTt＝Bpt/Apt・Apr/(Apr＋Bpr)・ATt
Apr, FER, Bpr
(Bpr, FER, Apr)
＊SHO中のみ
ATt：BS(A)のトラフィックチャネル送信電力
BTt：BS(B)のトラフィックチャネル送信電力
MS
3

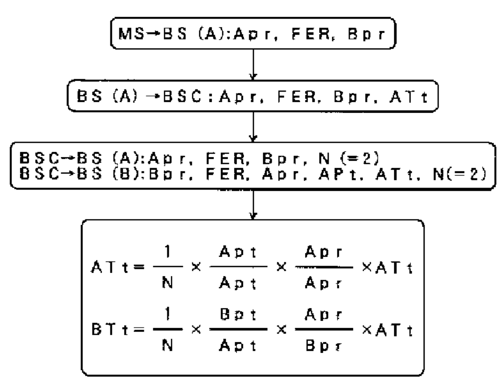
【図3】


BSC
4
Apr, Bpt, Bpr, FER
Apt, Apr, Bpr, FER, ATt
Apr, FER, Bpr, ATt
(Bpr, FER, Apr)
＊SHO中のみ
Apt：A局のパイロット送信電力
Bpt：B局のパイロット送信電力
BS (A)
1
BS (B)
2
ATt＝(Apr・Apr/Apt)/((Apr)²/Apt＋(Bpr)²/Bpt)・ATt
BTt＝(Bpr・Apr/Apt)/((Apr)²/Apt＋(Bpr)²/Bpt)・ATt
Apr, FER, Bpr
(Bpr, FER, Apr)
＊SHO中のみ
MS
3

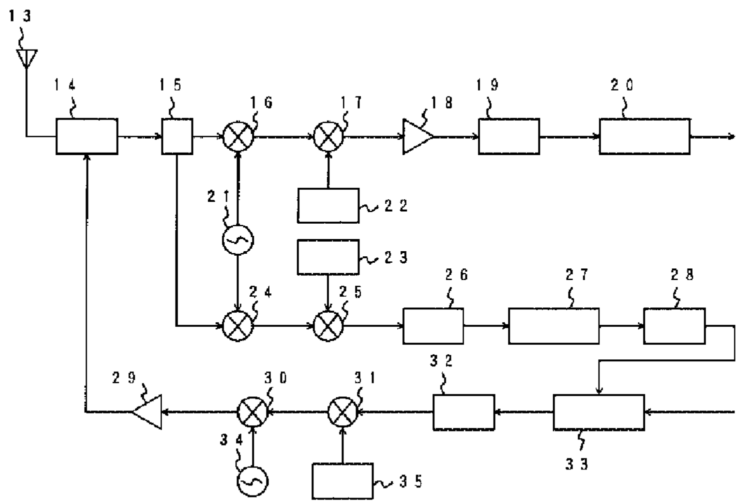
【図4】


5
6
7
8
9
10
11
12

【図6】


MS→BS (A):Apr, FER, Bpr
BS (A) →BSC:Apr, FER, Bpr, ATt
BSC→BS (A):Apr, FER, Bpr, N (=2)
BSC→BS (B):Bpr, FER, Apr, APt, ATt, N(=2)
ATt＝1/N×Apt/Apt×Apr/Apr×ATt
BTt＝1/N×Bpt/Apt×Apr/Bpr×ATt

【図５】



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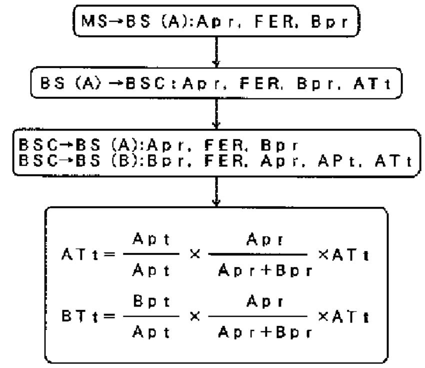

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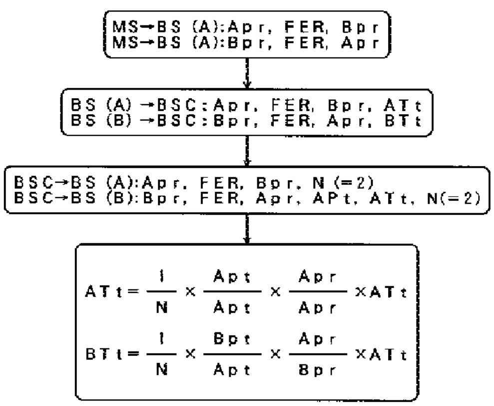
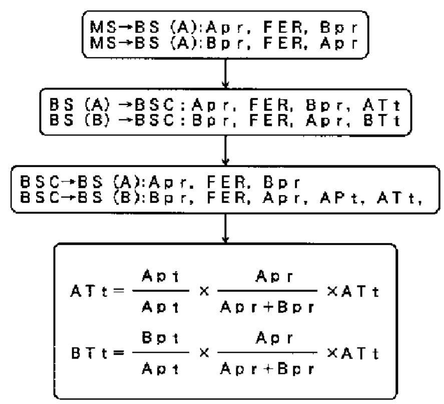
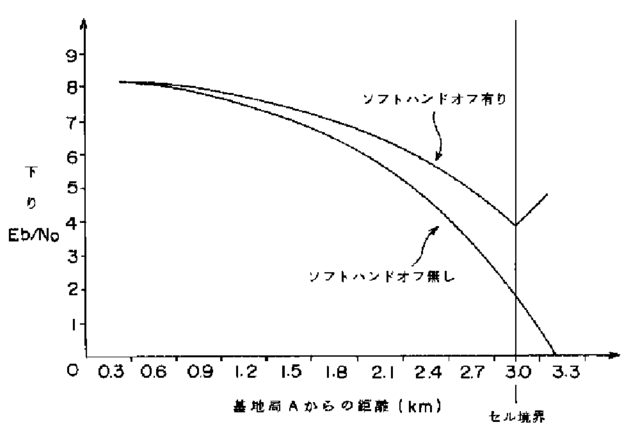


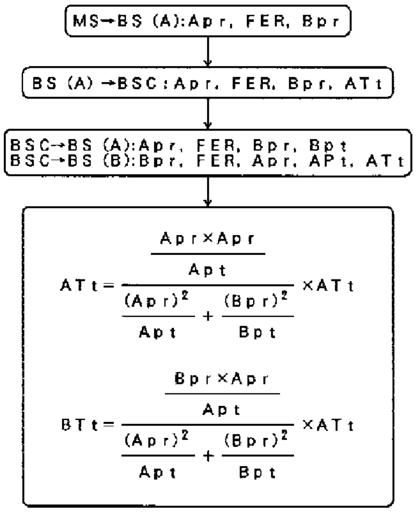
【図９】



【図１２】

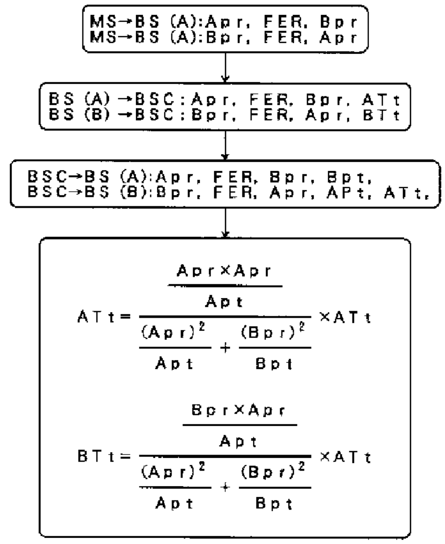


【図１０】



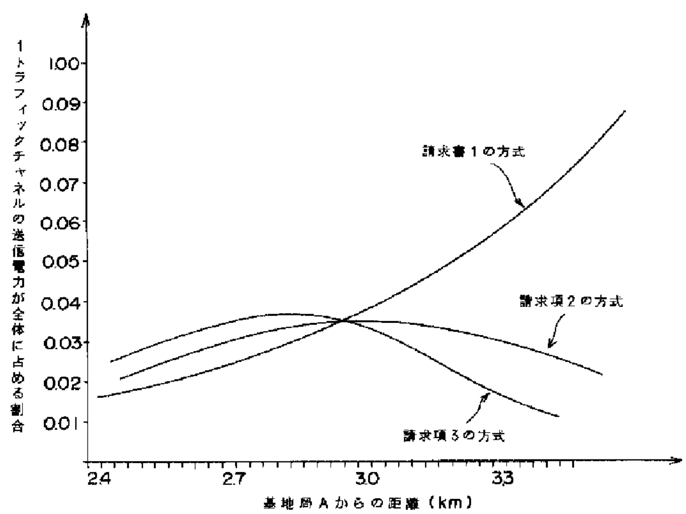
MS→BS (A):Apr, FER, Bpr
BS (A) →BSC:Apr, FER, Bpr, ATt
BSC→BS (A):Apr, FER, Bpr, Bpt
BSC→BS (B):Bpr, FER, Apr, APt, ATt
$$ATt=\frac{\frac{Apr\times Apr}{Apt}}{\frac{(Apr)^2}{Apt}+\frac{(Bpr)^2}{Bpt}}\times ATt$$
$$BTt=\frac{\frac{Bpr\times Apr}{Apt}}{\frac{(Apr)^2}{Apt}+\frac{(Bpr)^2}{Bpt}}\times ATt$$

【図１１】



MS→BS (A):Apr, FER, Bpr
MS→BS (A):Bpr, FER, Apr
BS (A) →BSC:Apr, FER, Bpr, ATt
BS (B) →BSC:Bpr, FER, Apr, BTt
BSC→BS (A):Apr, FER, Bpr, Bpt,
BSC→BS (B):Bpr, FER, Apr, APt, ATt,
$$ATt=\frac{\frac{Apr\times Apr}{Apt}}{\frac{(Apr)^2}{Apt}+\frac{(Bpr)^2}{Bpt}}\times ATt$$
$$BTt=\frac{\frac{Bpr\times Apr}{Apt}}{\frac{(Apr)^2}{Apt}+\frac{(Bpr)^2}{Bpt}}\times ATt$$

【図１３】



1トラフィックチャネルの送信電力が全体に占める割合
1.00
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
請求書1の方式
請求項2の方式
請求項3の方式
2.4
2.7
3.0
3.3
基地局Aからの距離（km）

US005734646A

United States Patent [19]

I et al.

[11] Patent Number: 5,734,646

[45] Date of Patent: Mar. 31, 1998

[54] **CODE DIVISION MULTIPLE ACCESS SYSTEM PROVIDING LOAD AND INTERFERENCE BASED DEMAND ASSIGNMENT SERVICE TO USERS**

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[73] Assignee: **Lucent Technologies Inc.**, Murray Hill, N.J.

[21] Appl. No.: **539,476**

[22] Filed: **Oct. 5, 1995**

[51] **Int. Cl.**^{6} **H04T 13/00**

[52] **U.S. Cl.** **370/335**; 370/342; 370/441; 370/468; 370/479; 370/252

[58] **Field of Search** 370/310, 313, 370/328, 329, 335, 342, 431, 437, 441, 464, 465, 479, 491, 500, 468, 252; 455/34.1, 54.1, 54.2, 56.1, 62, 33.1, 450, 452, 69; 379/58, 59, 60

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Variable Spreading Gain CDMA with Adaptive Control for True Packet Switching Wireless Network, C–L I, et al; IEEE, pp. 725 through 729, 1995.

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Performance of Multi–Code CDMA Wireless Personal Communications Networks, C–L I, et al; IEEE, pp. 907 through 911, 1995.

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Primary Examiner—Benedict V. Safourek
Assistant Examiner—Seema S. Rao

[57] **ABSTRACT**

A code division multiple access system provides a way of allocating an increased data rate to a requesting mobile station. A mobile station requesting a data rate in excess of the basic data rate sends received pilot strength data for its base station and base stations in adjacent cells. The received pilot strength data is used to determine an increased data rate to be assigned to the requesting mobile station. One feature assigns an increased data rate when the received pilot strength data has a predetermined relationship to an established threshold. Another feature utilizes a series of threshold levels, each pair of levels associated with a different permitted data rate. Using the received pilot strength data, a data rate is determined which satisfies all adjacent cell interference concerns. Another feature uses average adjacent cell capacity loads rather than threshold levels, together with the received pilot strength data, to determine the appropriate increased data rate to be assigned to a user requesting an increased data rate.

25 Claims, 9 Drawing Sheets

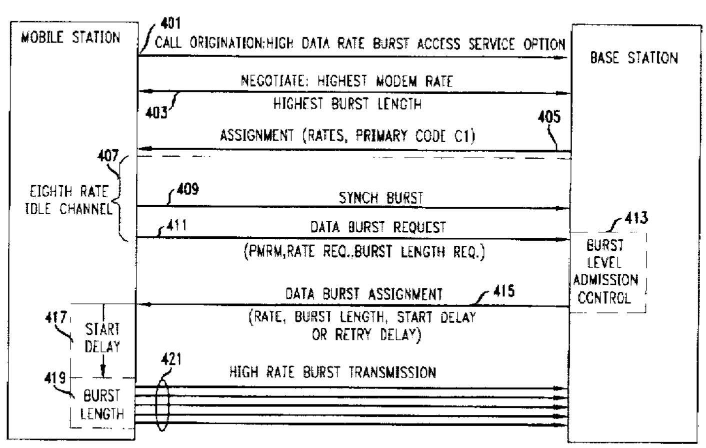
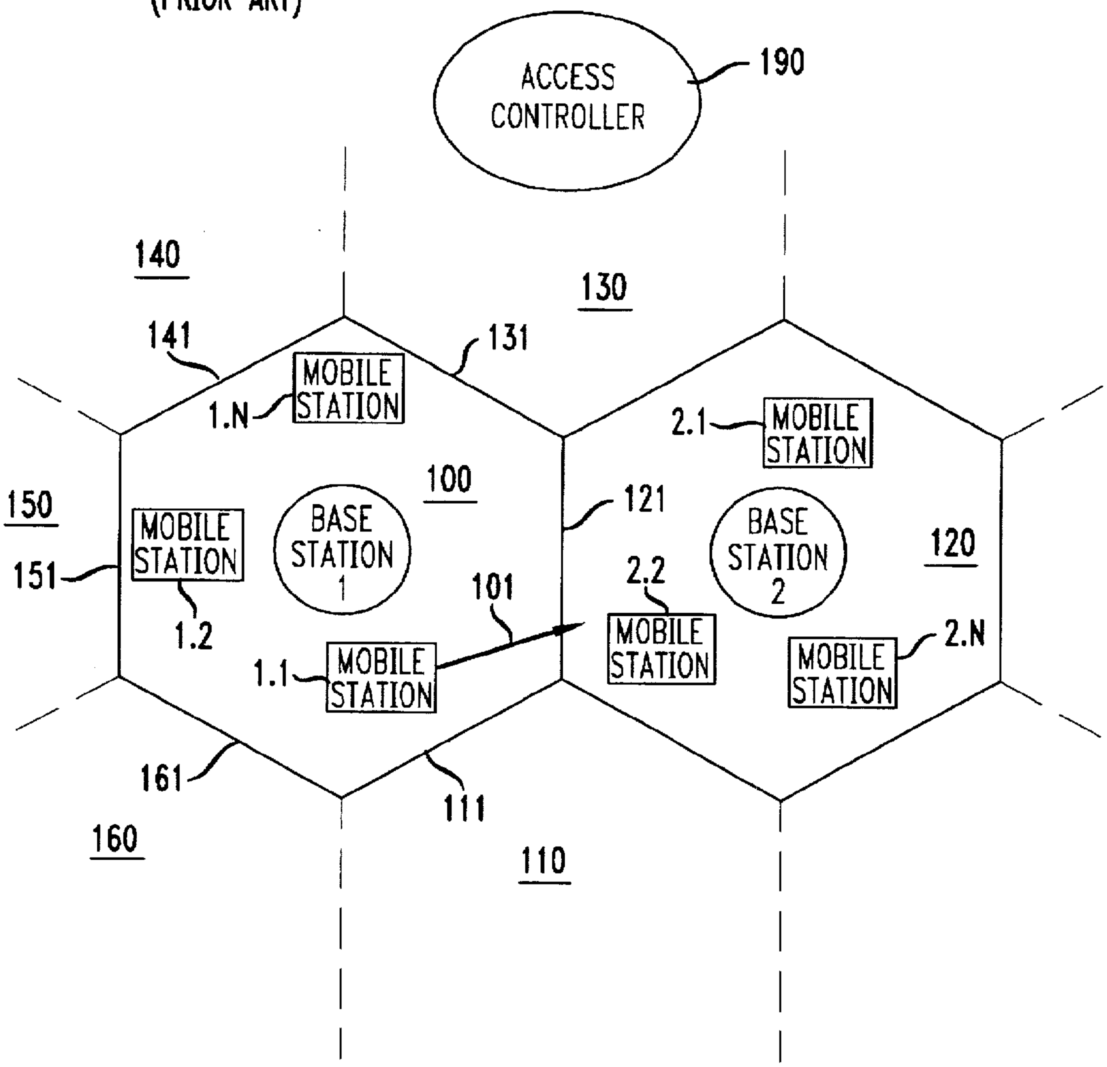
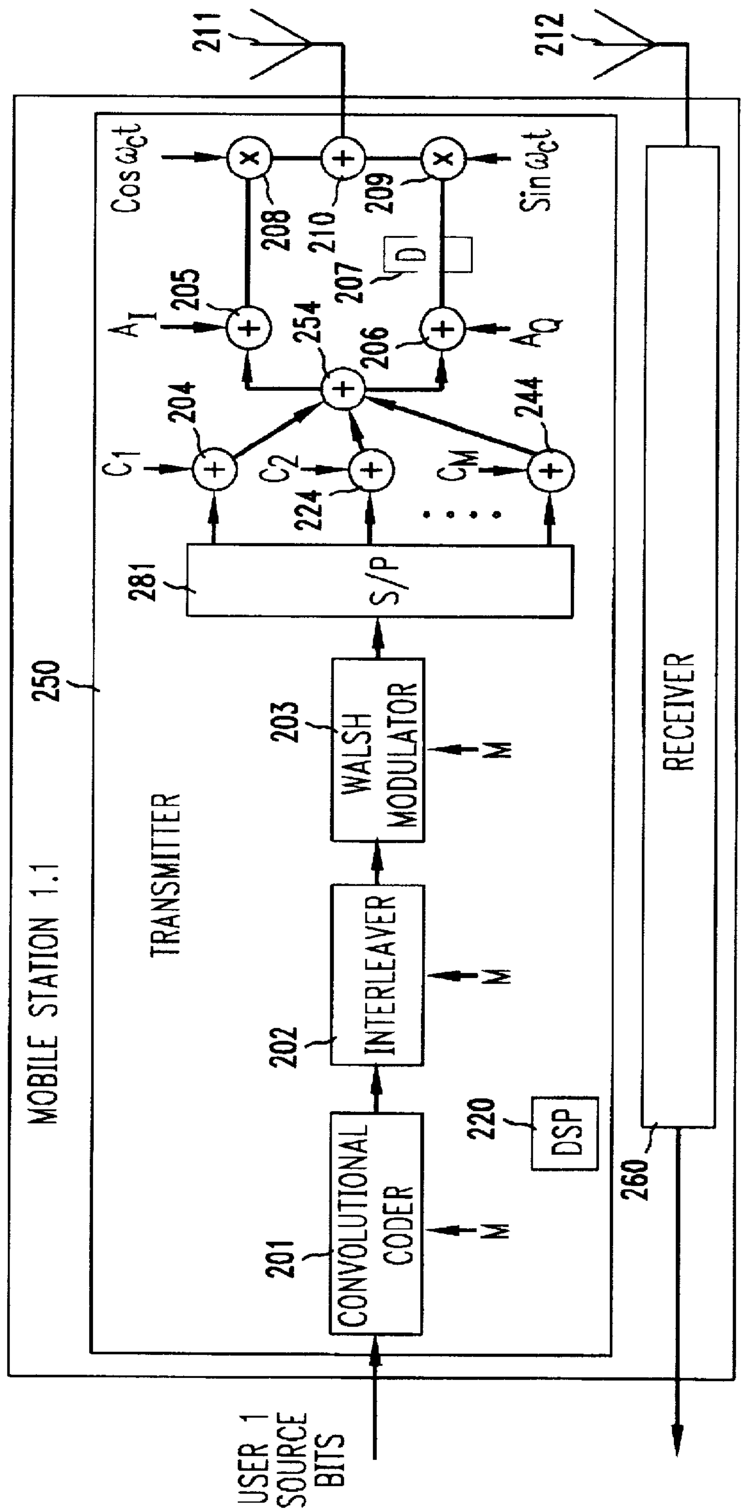


FIG. 1
(PRIOR ART)





MOBILE STATION 1.1
250
TRANSMITTER
USER 1 SOURCE BITS
CONVOLUTIONAL CODER
201
M
INTERLEAVER
202
M
WALSH MODULATOR
203
M
DSP
220
S/P
281
C_1
204
C_2
224
C_M
244
254
A_I
205
A_Q
206
D
207
208
209
210
$\cos\omega_c t$
$\sin\omega_c t$
211
212
RECEIVER
260

FIG. 2

FIG. 3

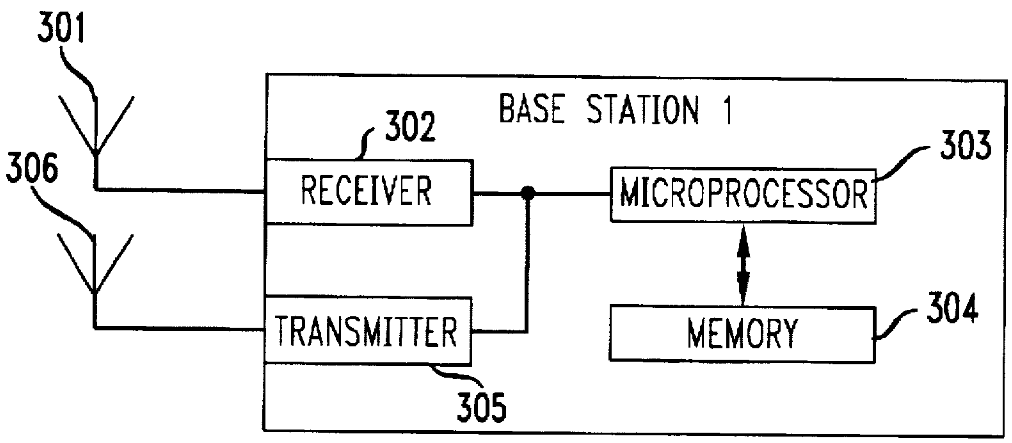
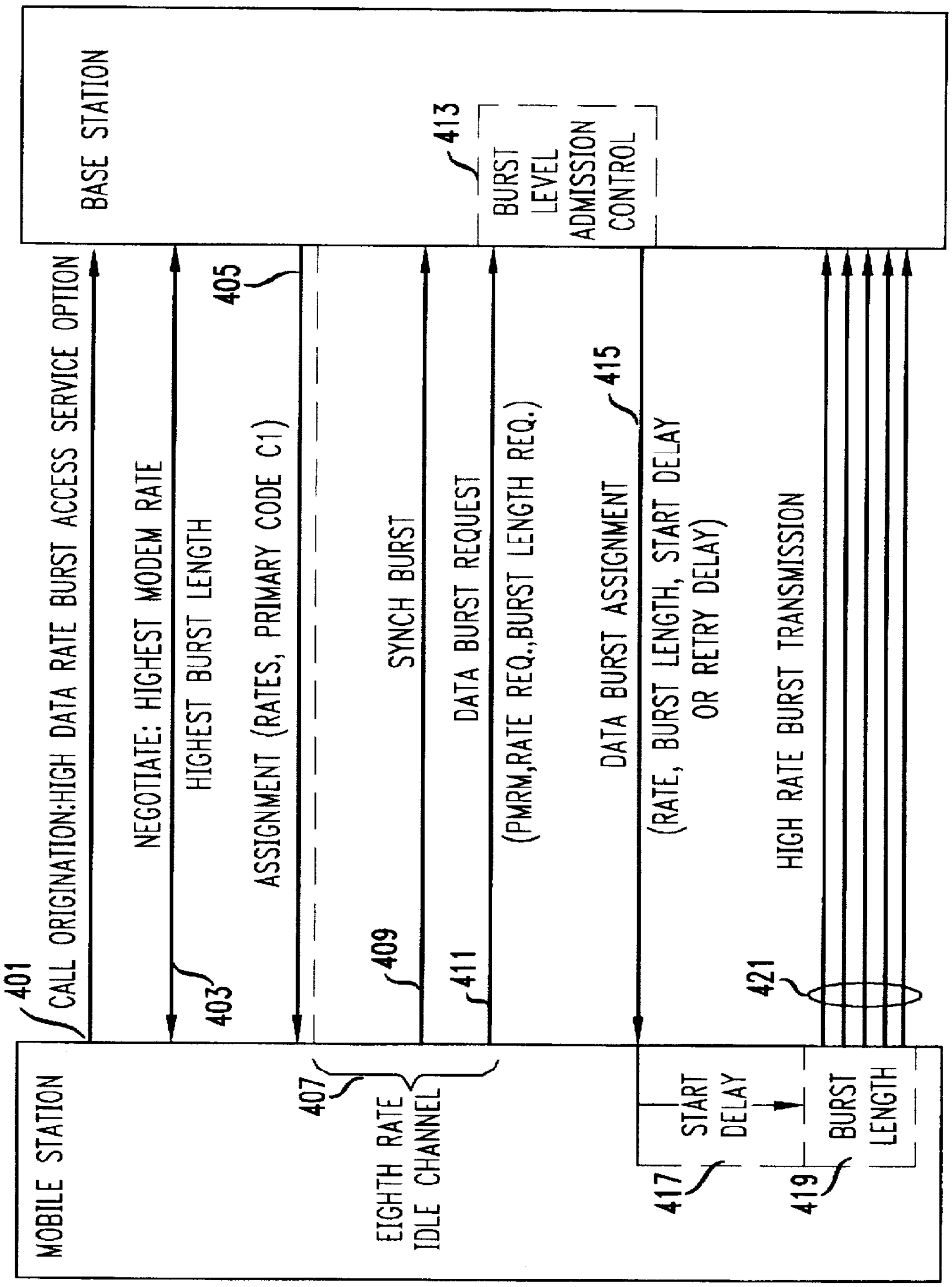

301
306
BASE STATION 1
302
RECEIVER
303
MICROPROCESSOR
TRANSMITTER
MEMORY
304
305

FIG. 4


BASE STATION
MOBILE STATION
401
CALL ORIGINATION:HIGH DATA RATE BURST ACCESS SERVICE OPTION
403
NEGOTIATE: HIGHEST MODEM RATE
HIGHEST BURST LENGTH
405
ASSIGNMENT (RATES, PRIMARY CODE C1)
407
EIGHTH RATE
IDLE CHANNEL
409
SYNCH BURST
411
DATA BURST REQUEST
(PMRM,RATE REQ.,BURST LENGTH REQ.)
413
BURST
LEVEL
ADMISSION
CONTROL
415
DATA BURST ASSIGNMENT
(RATE, BURST LENGTH, START DELAY
OR RETRY DELAY)
417
START
DELAY
419
BURST
LENGTH
421
HIGH RATE BURST TRANSMISSION

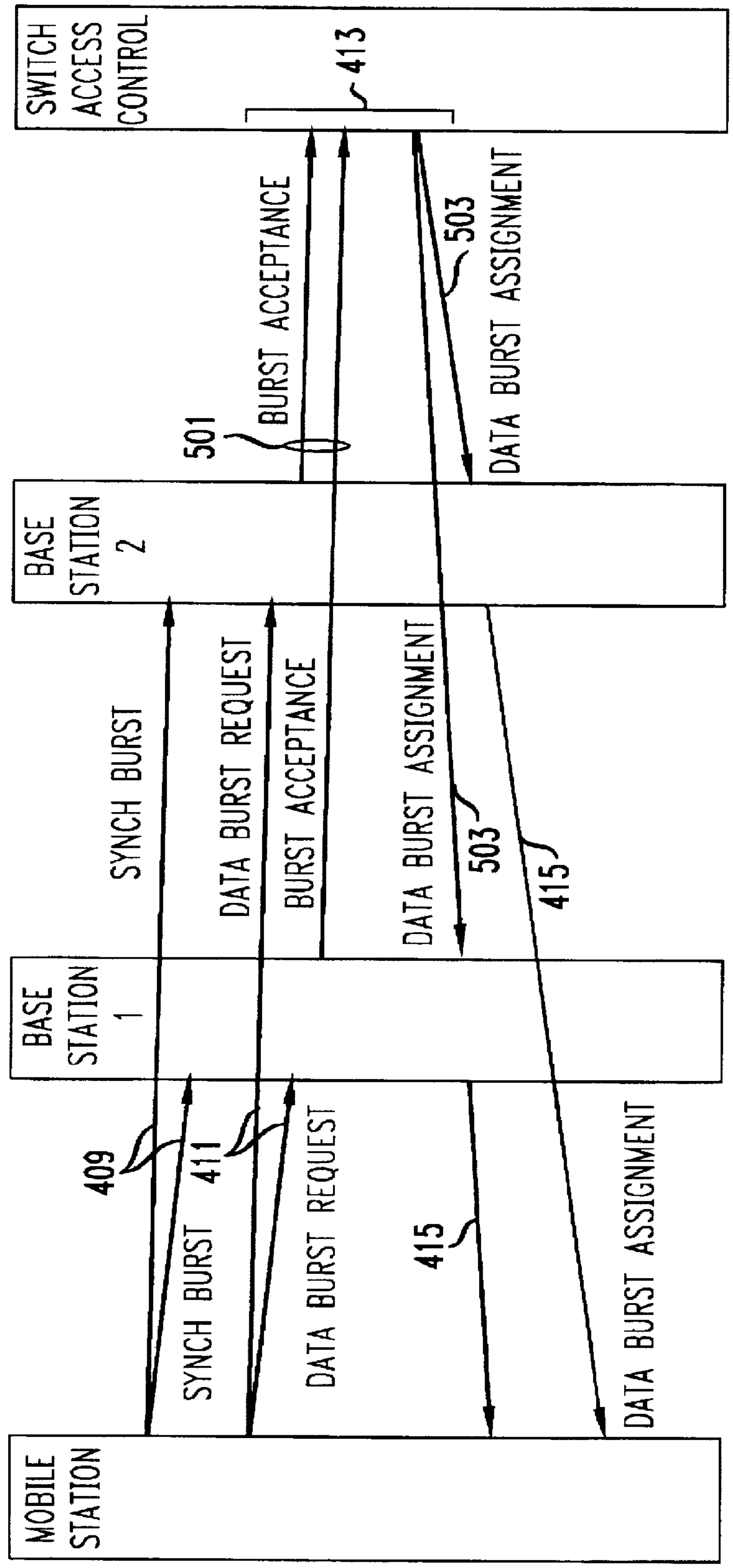

SWITCH ACCESS CONTROL
413
BURST ACCEPTANCE
503
DATA BURST ASSIGNMENT
501
BASE STATION 2
SYNCH BURST
DATA BURST REQUEST
BURST ACCEPTANCE
DATA BURST ASSIGNMENT
503
415
BASE STATION 1
409
SYNCH BURST
411
DATA BURST REQUEST
415
DATA BURST ASSIGNMENT
MOBILE STATION

FIG. 5

FIG. 6

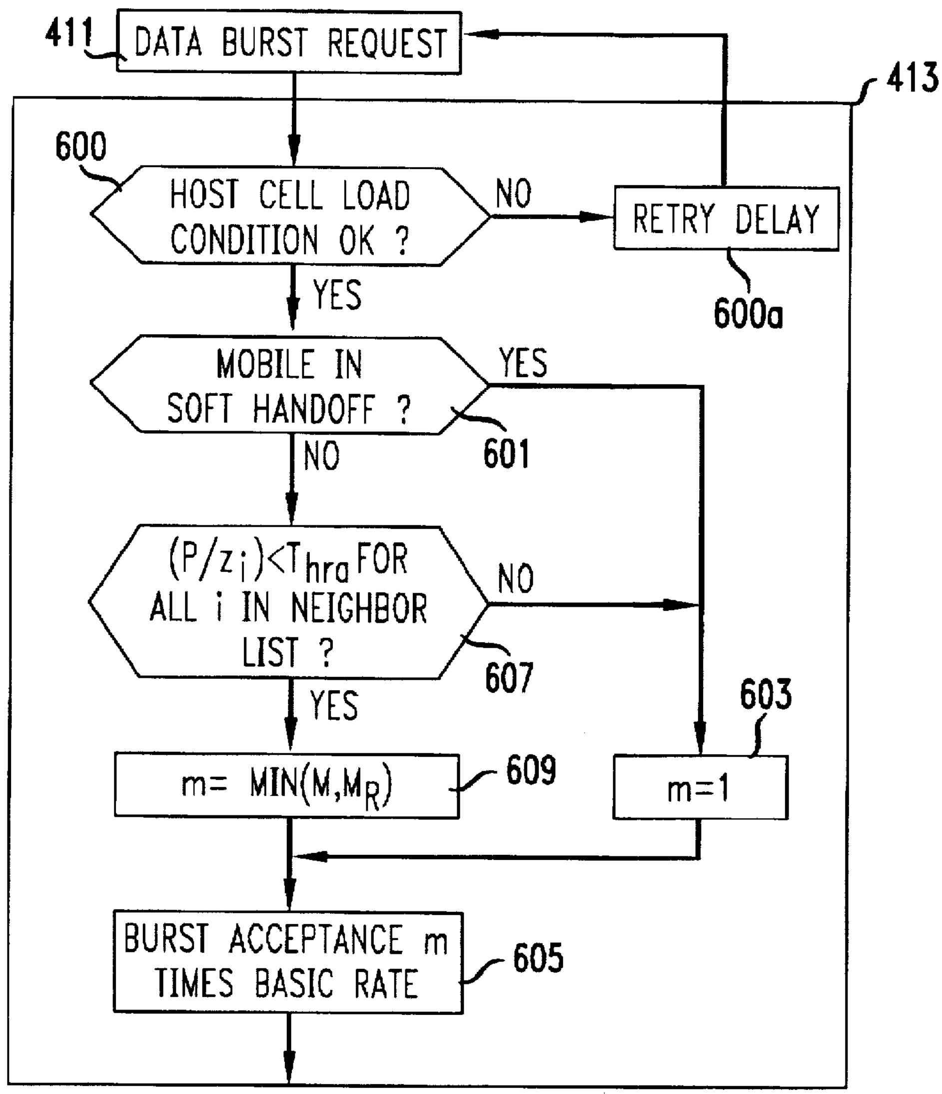

411
DATA BURST REQUEST
413
600
HOST CELL LOAD CONDITION OK ?
NO
RETRY DELAY
600a
YES
MOBILE IN SOFT HANDOFF ?
YES
NO
601
$(P/z_i)<T_{hra}$ FOR ALL i IN NEIGHBOR LIST ?
NO
607
YES
603
m= MIN(M,M$_R$)
609
m=1
BURST ACCEPTANCE m TIMES BASIC RATE
605

FIG. 7

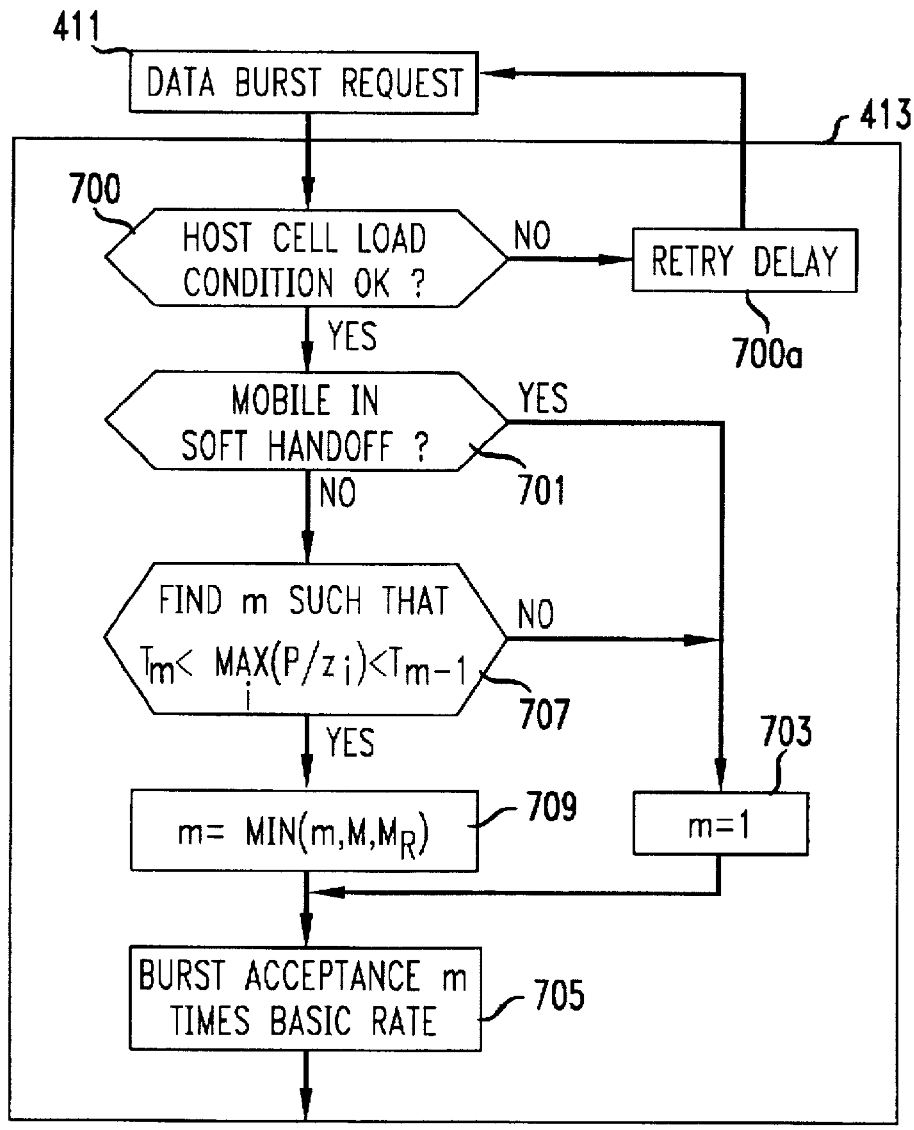
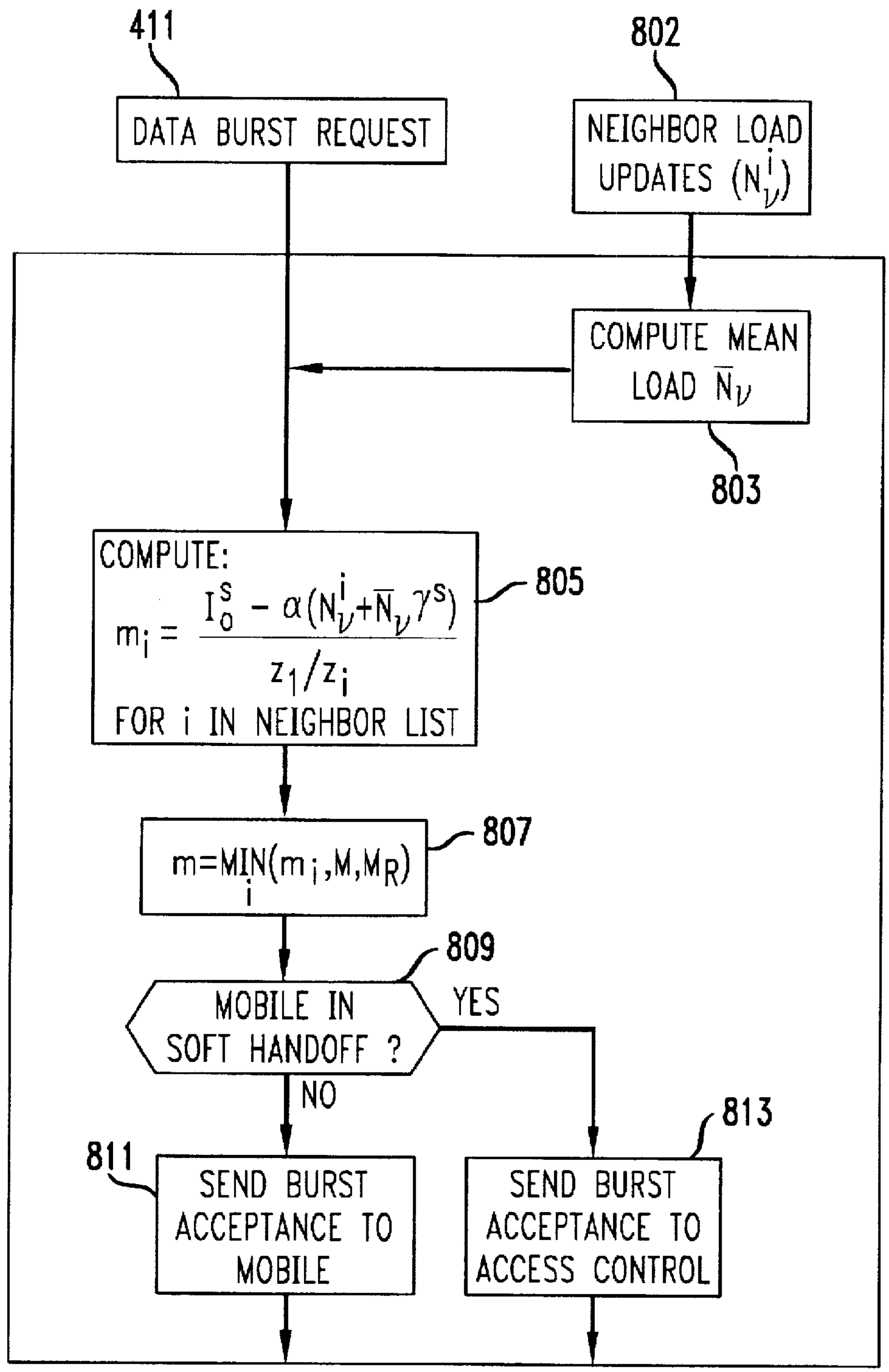
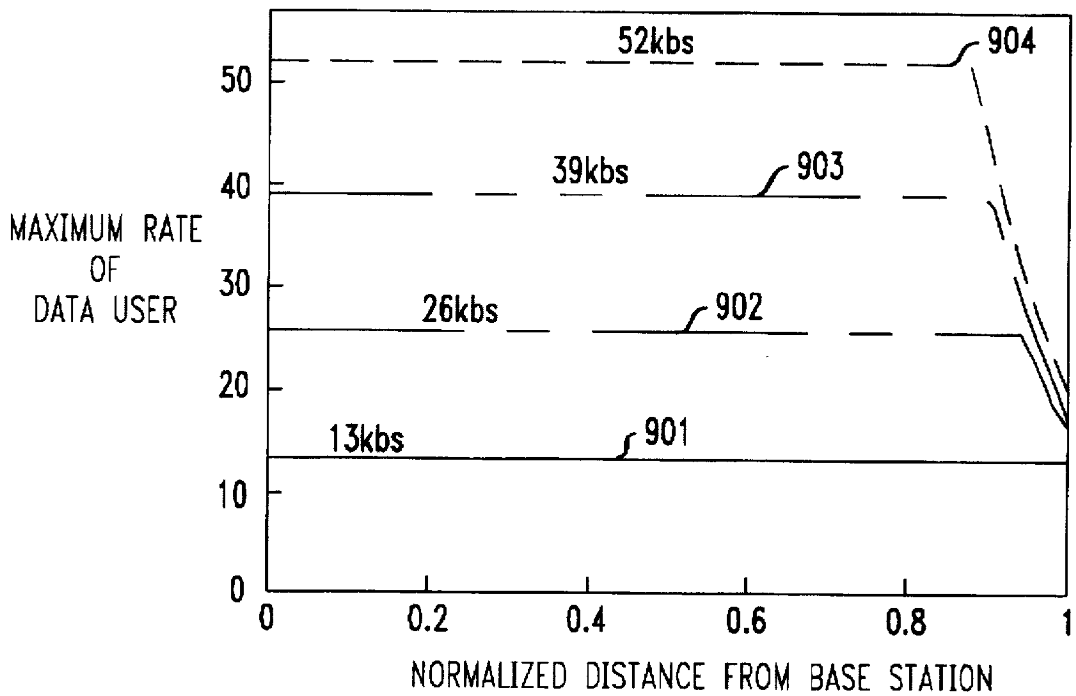

411
DATA BURST REQUEST
413
700
HOST CELL LOAD CONDITION OK ?
NO
RETRY DELAY
700a
YES
MOBILE IN SOFT HANDOFF ?
YES
701
NO
FIND m SUCH THAT
$T_m < \underset{i}{MAX}(P/z_i) < T_{m-1}$
NO
707
YES
703
m= MIN(m,M,M_R)
709
m=1
BURST ACCEPTANCE m TIMES BASIC RATE
705

FIG. 8



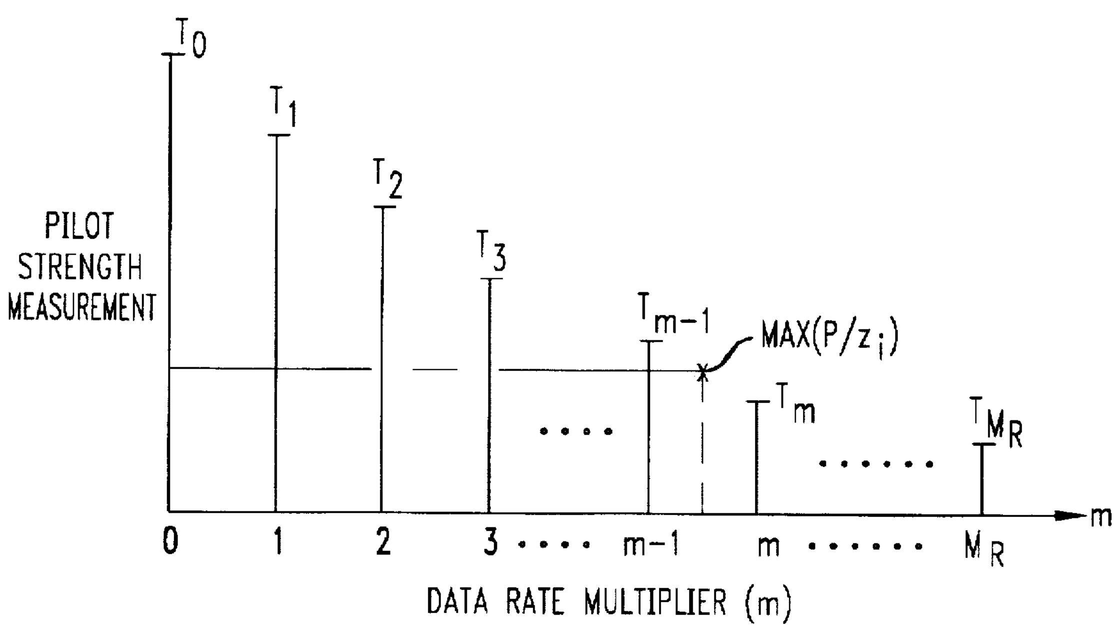
411
DATA BURST REQUEST
802
NEIGHBOR LOAD UPDATES (N_ν^i)
COMPUTE MEAN LOAD $\overline{N}_\nu$
803
COMPUTE:
$m_i = \dfrac{I_o^s - \alpha(N_\nu^i + \overline{N}_\nu \gamma^s)}{z_1/z_i}$
FOR i IN NEIGHBOR LIST
805
$m = \underset{i}{\mathrm{MIN}}(m_i, M, M_R)$
807
809
MOBILE IN SOFT HANDOFF ?
YES
NO
811
SEND BURST ACCEPTANCE TO MOBILE
813
SEND BURST ACCEPTANCE TO ACCESS CONTROL

FIG. 9



52kbs
904
39kbs
903
26kbs
902
13kbs
901
MAXIMUM RATE OF DATA USER
0
10
20
30
40
50
0
0.2
0.4
0.6
0.8
1
NORMALIZED DISTANCE FROM BASE STATION

FIG. 10



T_0
T_1
T_2
T_3
T_{m-1}
MAX(P/z$_i$)
T_m
T_{M_R}
PILOT STRENGTH MEASUREMENT
0
1
2
3 ....
m-1
m ....
M_R
m
DATA RATE MULTIPLIER (m)

CODE DIVISION MULTIPLE ACCESS SYSTEM PROVIDING LOAD AND INTERFERENCE BASED DEMAND ASSIGNMENT SERVICE TO USERS

TECHNICAL FIELD OF THE INVENTION

This invention relates to code division multiple access (CDMA) systems and, more particularly, to a CDMA system for allocating data rate to a user based on the load and interference of the system.

BACKGROUND OF THE INVENTION

The advantages of code division multiple access (CDMA) for cellular voice have become well known. In contrast to orthogonal systems such as time division multiplex access (TDMA) or frequency division multiplex access (FDMA), frequency planning or "orthogonality" coordination (channel allocation) between cells and within the same cell are greatly simplified. The reason is that, unlike TDMA and FDMA where the re-use constraints must account for the worst case (or 95th percentile) interferer, re-use in CDMA is based on the average interference seen from a large number of low power users. Due to this interference averaging property, CDMA simply translates voice activity factor and antenna sectorization into capacity gains. Furthermore, RAKE receivers resolve the multipath components of the spread spectrum signal and translate it into diversity gain.

In spite of the advantages, conventional CDMA systems have very limited per user throughput and are not well suited to "bandwidth on demand" local area network (LAN)-like applications. In fact, current CDMA standards operate in circuit mode, assume a homogeneous user population, and limit each user to a rate which is a small fraction of the system capacity. As mentioned above, CDMA relies on the averaging effect of the interference from a large number of low-rate (voice or circuit-mode data) users. It relies heavily on sophisticated power control to ensure that the average interference from all users from an adjacent cell is a small fraction of the interference from the users within a cell. The imperfect power control in a homogeneous system has a direct impact on system performance.

Moreover, even with perfect power control, users at higher data rates in a system with mixed traffic result in large adjacent cell interference variations which drastically degrade the system capacity. This problem has so far precluded the provision of high data rate services in cellular CDMA.

SUMMARY OF THE INVENTION

Our inventive Load and Interference based Demand Assignment (LIDA) techniques protect voice (and other high priority or delay sensitive) isochronous users while accommodating the peak data rate needs of high data rate users when the load on the system permits. More particularly, our method and apparatus provides a code division multiple access system including a plurality of cells, each cell having a base station and multiple mobile stations, with a way of allocating an increased data rate to a requesting mobile station. Initially, the system receives a data burst request from a mobile station that has an established high burst rate data call in a first cell requesting a data rate in excess of the basic data rate B allocated to that mobile station. The data burst request includes pilot strength information (e.g., pilot measurement report message of IS-95) for a base station of the first cell and at least one cell adjacent to the first cell. Assuming a known level of load in the first cell, an access controller uses the received pilot strength to determine if an increased data rate is to be granted to the requesting mobile station. If granted, a data burst assignment response is transmitted from the access controller to the requesting mobile station. One feature enables the access controller to compare the received pilot strength with a threshold (e.g., an interference level indicator). When the received pilot strength has a predetermined relationship to the threshold, the data burst assignment response indicates an increased data rate has been granted to the requesting mobile station. When a plurality of adjacent cells (also referred to herein as neighbor cells) exists, the increased data rate is at the requested first data rate when the pilot strengths received from all of the base stations at the plurality of adjacent cells do not exceed the threshold.

Another feature utilizes a series of threshold levels, each associated with a different permitted data rate. Using the received pilot strength information, a data rate is determined which satisfies all adjacent cell interference concerns. According to another feature, average adjacent cell loads are utilized rather than threshold levels, together with the pilot strength information, to determine the appropriate increased data rate to be assigned to a user requesting an increased data rate.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing,

FIG. 1 shows a prior art CDMA system in which the present invention may be utilized;

FIG. 2 shows a block diagram of an illustrative mobile station of the CDMA system of FIG. 1;

FIG. 3 shows a block diagram of an illustrative base station of the CDMA system of FIG. 1;

FIG. 4 shows a flow diagram describing how a base station provides load and interference based demand assignment services to a mobile user in accordance with the present invention;

FIG. 5 shows a flow diagram of how the switch access controller coordinates a soft handoff between cells;

FIG. 6 shows a flow chart of the autonomous access control feature of the present invention;

FIG. 7 shows a flow chart of an enhanced autonomous access control feature;

FIG. 8 shows a flow chart of a neighbor coordinated access control;

FIG. 9 shows an illustrative graph of the data rates allowed to a user as a function of distance to the base station; and

FIG. 10 shows an illustrative graph of the received pilot strength measurements versus the data rate multiple m.

GENERAL DESCRIPTION

To curtail the potentially large interference variation in cellular CDMA systems serving mixed traffic, the present invention incorporates autonomous and/or coordinated network access control that accounts for channel loading and interference. It dynamically assigns higher data rates to users while simultaneously adjusting the Quality of Service (QOS) for each user according to service requirements. Higher data rates are assigned to users by either permitting users to transmit on multiple channels simultaneously or by using other means, such as variable spreading gains, variable channel coding rate, variable chip rate, varying the modu-

lation (Walsh modulation, coded modulations, BPSK, QPSK . . .) etc. An elegant scheme that achieves this is Multi-Code CDMA (MC-CDMA) with dynamic demand assignment, described in U.S. Pat. No. 5,442,625 entitled "Code Division Multiple Access System Providing Variable Data Rate Access" which issued on Aug. 15, 1995 to Richard D. Gitlin and Chih-Lin I. The QOS is adjusted through the power control with a target Frame Error Rate (FER) and signal to interference ratio (E_b/N_0) on the channel. In this invention, the network uses a control strategy that accounts for channel loading, interference, and soft handoff in making the rate assignment and QOS decisions. It ensures priority for voice users, if so desired. Thus, dynamic, packet-like demand-assigned access enables users with different services to access the channel at desired rates and QOS requirements.

Our autonomous network access control is referred to herein as the Load and Interference Based Demand Assignment (LIDA) for providing dynamic demand-assigned burst access in a wireless CDMA network. LIDA ensures protection of voice (and other high priority or delay sensitive) isochronous users, but allows peak rate access by high data rate users when the load on the channel permits. With best-effort type QOS guarantees, the high data rate service is best suited for typical LAN- and Wide Area Network WAN-type computer applications (including services based on mobile IP (as discussed by C. Perkins in "IP Mobility Support," *Internet Engineering Task Force,* Mar. 21, 1995) and CDPD ("Cellular Digital Packet Data System Specification: Release 1.1," *CDPD Forum, Inc.,* Jan. 19, 1995)), less so for high rate applications with stringent real time constraints.

DETAILED DESCRIPTION

In the following description, each item or block of each figure has a reference designation associated therewith, the first number of which refers to the figure in which that item is first located (e.g., **110** is located in FIG. 1).

With reference to FIG. 1, we describe a prior art multicode (MC) CDMA system. The illustrative MC-CDMA system includes a regular hexagonal grid of cell sites **100**, **110**, **120**, **130**, **140**, **150** and **160**, each including a plurality of mobile stations (e.g, MS1.1–MS1.N) which enables each of a plurality of users (1–N) to communicate with its associated base station BS1 within a cell site. Illustratively, cell site **120** includes base station BS2 and mobile stations MS2.1–MS2.J.

Our LIDA control, as will be described in a later paragraph, may be implemented in each base station, e.g., BS1–BS2, etc. In one embodiment of the present invention, an access controller **190** is utilized to provide coordinated access control (FIG. 1) between neighboring base stations (e.g., between BS1 and BS2). In such an arrangement, access controller **190** communicates with all of the base stations to control the assignment of a higher-than-basic data rate and burst length. While the access controller **190** is shown in a separate location, it may be co-located with a base station or the central switch.

Radio distance is the effective radio loss that a signal, transmitted from a base station, incurs in transit to a mobile station. The received pilot power Pi at a mobile station is then P/z_i, where P is the transmitted pilot power from each base station and z_i is the effective "radio distance." As a mobile station MS1.1 in cell **100** approaches cell **120**, the power level of the received pilot from base station BS2 increases beyond a threshold, T_{add}, and the mobile station will enter "soft handoff." During soft handoff, the mobile station communicates with both base stations BS1 and BS2. We extend the use of the pilot measurement to burst access control in this invention.

With reference to FIG. 2, an illustrative block diagram of mobile station MS1.1 is shown to include a transmitter station **250** and a receiver station **260**. Illustrative examples of mobile stations are described in the previously reference U.S. Pat. No. 5,442,625. The transmitter station **250** includes a convolutional coder **201** which receives digital information (or data signals) from user **1** at a first data bit rate. The output of convolutional coder **201** is coupled to interleaver **202** and then to a Walsh modulator **203**, all of which are well known in the prior art. The serial-to-parallel (S/P) station **281** is connected to the output of the Walsh modulator **203** and converts the user's input digital information stream into M basic data rate serial information streams. In the following, we use MC-CDMA as an illustrative method of providing higher data rates.

The serial-to-parallel station **281** converts a user's serial digital information input, which may be up to M_{max} times the basic source rate B (where $M_{max} \cdot B \leq$ channel rate), into M data streams (where M is an integer $\leq M_{max}$). The outputs of S/P station **281** connect to code spreaders **204**, **224**, and **244**, which spread each of the M data streams, respectively, into a channel bit rate using codes C_1, C_2, and C_M which are unique to user **1**. The combiner **254** combines the output of code spreaders **204**, **224** and **244**. The output signal combiner **254** is coupled to coders **205** and **206**. In coder **205**, an in-phase code A_I further encodes the signal from combiner **254**. Similarly, coder **206** further encodes the signal from combiner **254** using a quadrature-phase code A_Q. The codes A_I and A_Q are common to all mobile stations of FIG. **1**.

The output of coder **205** is used to modulate the carrier signal $\text{Cos}\omega_c t$ in modulator **208**. The output of coder **206** is used to modulate the carrier signal $\text{Sin}\omega_c t$ in modulator **209**. In certain applications, an optional delay station **207** may be utilized to provide better spectral shaping. The output of modulators **208** and **209** are radio frequency signals which are combined in combiner **210** and transmitted via antenna **211** over the air to a base station (e.g., BS1 of FIG. 1).

A base station (e.g., BS1) transmits at a different carrier frequency which is received and decoded by mobile stations MS1.1–MS1.N within its cell site **100**. In our illustrative example, receiver **260** of mobile station MS1.1 includes a demodulator (not shown) to demodulate the carrier frequency to obtain a channel bit rate signal which is decoded using codes A_I and A_Q and then de-spread using the associated code sequence C_1 to obtain the information data signal to be outputted to user 1.

The base station, e.g., BS1, operates in a similar manner to receiver **260** of mobile station MS1.1 to receive, decode and de-spread the user 1 information data signal. Similarly, the other mobile stations, illustratively represented by mobile station MS1.N, operate in the same manner as mobile station MS1.1, except that user N has a unique code C_N to distinguish it from user 1. In mobile station MS1.N, the in-phase and quadrature codes A_I and A_Q, respectively, as well as the carrier frequency f_c are the same as those used for mobile station MS1.1.

With reference to FIG. 3, there is shown an illustrative block diagram of base station BS1. The modulated carrier signal is received at antenna **301** and processed by MC-CDMA receiver **302** under control of processor **303**. The receiver **302** operates in a similar manner to the previously described MC-CDMA receiver **260** of mobile station MS1.1 of FIG. 2. Similarly, the MC-CDMA transmitter **305**

transmits via antenna **311** and operates in a similar manner to transmitter **250** previously described.

Processor **303**, acting under control of programs resident in memory **304**, controls the operation of MC-CDMA receiver **302**, MC-CDMA transmitter **305** performs typical well-known base station functions and may perform for cell **100**, as well, some or all of the load and interference based demand assignment (LIDA) function in accordance with the present invention. This LIDA function is shown in FIGS. **4–9** and is described in later paragraphs. However, the standard functions performed by base station BS1 which are not pertinent to the understanding of the present invention are not discussed herein.

Interference Calculations

With continued reference to FIG. **1**, we start by investigating the in-cell and out-of-cell interference caused by a single high rate data user (using multiple codes). The results confirm the need of our demand assignment coupled with network control algorithms, LIDA. The procedure of LIDA algorithms allowing burst access at rates up to M times the basic rate is generally based on the following:

the load information in the cell and its neighbors;

the pilot strength measurements provided by the mobile;

coordination of the burst rate, burst length and burst starting time between neighbor cells.

Coordination of system resources between data users capable of high bit rate burst mode operation and high priority voice users can be managed through LIDA. The LIDA algorithms with various levels of complexity are presented below. To simplify the discussion, we describe the control procedures for the system with a single data user. Procedures for multiple data users are very similar. The control mechanism presented herein is essential to provide a shared burst mode access mechanism over CDMA and is claimed here as a new invention.

In the following description, we assume a CDMA cellular system of FIG. **1** having power control and including only voice users at the various mobile stations MS1.1–MS1.N, MS2.1–MS2.J. Consider cell site **100**: when only voice users are served, each in-cell interferer (e.g., MS1.1) causes identical interference at the base station BS1, and therefore appears to be exactly one user, while the average out-of-cell interferer (e.g., MS2.1), aggregated from all cells, in a regular hexagonal grid cellular system **110–160** appear to be γ users. Assuming a path loss exponent of 4, γ is around 0.5. In a system with N voice users per cell, the total interference at each base station is:

$$I_0=\alpha N(1+\gamma) \tag{1}$$

where α is the speech activity factor. We use the nominal interference, I_0, in a voice-only system with a capacity of N users per cell, as the reference QOS in the subsequent discussion.

Let us now examine the in-cell interference with a single data user at time 't' transmitting at M times the basic rate (9.6 kbps or 14.4 kbps, depending on the reference system configuration). Assuming a speech activity factor α around 0.4, under ideal power control, an active data user is equivalent to 2.5M (=M/α) voice users in its cell. If M=4, the data user consumes the equivalent resources of 10 voice users; i.e., the "equivalent load" of such a data user is 10. With a typical capacity of 15–25 voice users per cell, it is easy to see that a single high rate data user has a large impact on the cell capacity. (Obviously, a mobile station data user's activity factor would affect its average demand; however, the demand assignment of a high data rate burst must account for the maximum interference generated by the data user during its high data rate transmission.)

The impact on out-of-cell interference is considered next. In the voice-only system, where voice users are uniformly distributed in the cells **110–160**, most of the out-of-cell interference comes from the users in other cells (e.g., MS2.1) that are near the cell boundaries **111–161**. Due to the large path loss exponent, users further away from the boundary (e.g., MS2.N) contribute little to out-of-cell interference. As the high data rate user (e.g., MS1.1), transmitting at M/α times the average data rate of a voice user, moves along path **101** closer to the boundary **121**, the in-cell interference to BS1 remains at around M/α while the out-of-cell interference to BS2, caused by the high rate data user, rapidly rises beyond what was computed for the voice system. However, to maintain the required Quality of Service (QOS), the total interference at each cell must be controlled to be no more than I_0.

To quantify our discussion above, assume there are N_v voice users per cell and one active (transmitting) high rate data user in the host cell, the total interference in the host cell and in the closest neighboring cell (with respect to that data user) can be expressed as follows:

$$I_d(r)=\alpha N_v(1+\gamma)+M\gamma_d(r), \tag{2}$$

where 'r' is the distance from the active high rate data to its host cell site. $\gamma_d(r)=1$ for the host cell since it is power controlled by that cell and $\gamma_d(r)\approx(2R-r)^4/r^4$ for the neighboring cell it approaches, where R is the cell radius. The access control mechanism for high rate data users must satisfy the constraint:

$$I_d(r)\leq I_0 \tag{3}$$

in both the host cell and the approached neighboring cell. We will seek to adjust N_v, the number of voice users, or M, the multiple of the basic data rate B being used by the data user, as a function of 'r', in order to meet the interference constraints. The issues and our strategies are elaborated in the next sections.

Interference Management Using Pilot Strength Measurements

In the above discussion, the out-of-cell interference due to a data user is a function of (2R−r)/r. Hence, the access controller should use the knowledge of the distance of the mobile from the cell site to determine permitted values of N_v and M. There are two issues with using 'r' as the control variable. First, the distance of the mobile from the cell site cannot be determined accurately. More importantly, although the discussion of out-of-cell interference above is in terms of the distance 'r', the actual interference is strongly dependent on the shadow fading conditions in addition to the distance. Hence, control based on geographic distance is neither optimal nor practical. The present invention uses a control based on radio distance, using pilot strength measurements to address both issues. This solution can easily be an integral part of a CDMA system.

In current CDMA systems, mobile assisted soft handoff is implemented as follows. The base station provides the mobile with a neighbor list of pilots. The mobile periodically measures the pilot strength on its neighbor list and transmits it to the cell site. If the pilot strength of a base station to which the mobile is not connected is greater than a threshold T_{add}, the base station initiates a soft handoff for the mobile. The present invention extends the concept of using pilot

strength measurements for soft handoff decisions to using it for access control of high data rate users.

With reference to FIG. 4, we describe a CDMA system of FIG. 1 incorporating our LIDA capability (hereinafter LIDA). In step **401**, a mobile originates a call requesting high data rate burst mode service option. In step **403**, the mobile and base station negotiate the highest modem rate and the highest burst length for the mobile.

As shown in step **405**, each user is assigned a unique primary code, i.e., C_1, determined as the user-specific PN sequence. When a user is quiescent, **407**, a very low rate (say, eighth rate) (sub-rate) signaling channel is maintained using its primary code. This sub-rate channel helps in maintaining synchronization and coarse power control. It is maintained whether the user is "connected" to one base station or is in soft handoff with multiple cells. Since the transmission during eighth rate frames is intermittent, both the synchronization and the power control are inadequate if the quiescent period is long.

Hence, any transmission from the mobile after a long quiescent period **407** may be lost. This problem is overcome by requiring the mobile to transmit a synch burst **409** of one (or more) basic rate frame(s) at the end of a "long" quiescent period. Following the synch burst that gives the receiver time to synchronize and provides power control feedback, the mobile station signals a request **411** for data burst transmission using signaling messages over the basic rate (B) channel. Alternately, instead of the synch burst in steps **407**, **409**, the mobile station could be required to transmit the request **411** multiple times.

The access request **411** from the mobile station contains the data rate requested and the burst length requested. The maximum burst length that may be requested by mobile is specified by the system (and is chosen to best coordinate shared access between users). In addition, to provide interference information to the base station, the access request from the mobile includes pilot strength information, e.g., PMRM (for base stations of cells in its neighbor list, for example, **MS1.1** would include pilot strength measurements on the base station of cells **110**–**160**). (Note, the inclusion of the pilot strength measurements within the access request is independent of (and in addition to) any such reports used for handling soft handoffs.) The pilot strength measurements received from the mobile (e.g., **MS1.1**) indicate to the base station (e.g., **BS1**) the interference levels that that mobile would generate at neighboring base stations (e.g., **BS2**). This measure of interference accounts for both the distance loss and shadow fading and thus is a measure of the radio distance to the neighboring base station, and will be used to make access control decisions of step **413**.

Specifically, in the presence of shadow fading, the average interference at the cell site for the basic voice-only system is modified from Equation 1 as described in the article by K. S. Gilhousen et al. entitled "On the Capacity of a Cellular CDMA System" (*IEEE Trans. Veh. Technol*, Vol. VT-40, No. 2, May 1991, pages 303–312). Let us denote it as $I_0^s=\alpha N(1+\gamma^s)$ where γ^s is the average out-of-cell interference in the presence of shadow fading. Similarly, in an integrated voice and data system, the interference factor for a data user in a neighboring cell is $\gamma_d^s(z_1,z_2)=z_1/z_2$, where z_1 and z_2 are the path loss of the mobile to the host cell and the neighboring cell, respectively. Note that $\gamma_d^s(z_1,z_2)=1$ in the case of the host cell because of power control. The path loss (radio distance) z_1 and z_2 include the distance loss component as well as the shadow fading component. The interference constraint becomes:

$$I_d^s(z_1,z_2)=\alpha N_v(1+\gamma^s)+M\gamma_d^s(z_1,z_2)\leqq I_0^s. \tag{4}$$

The values z_1 and z_2 are derived from the pilot strength measurements.

As will be described in FIG. **5**, step **413** is performed by an access controller located at the base station (or at one of the base stations in case of soft handoff) or at a separate location shown by **190** of FIG. 1. In step **415**, this assignment is then transmitted to the mobile. If the scheduled list is longer than the threshold L, the mobile is told to retry later (Retry Delay) in step **415**. The base station selects the value of this parameter based upon loading conditions at that base station. When a mobile receives a delay parameter in a data burst assignment message **415**, it initiates such a delay, step **417**, before starting its transmission of the assigned burst length, step **419**, and at the assigned data rate, step **421**. In an alternate embodiment, the mobile may be required to wait for an explicit BEGIN message to begin high data rate transmission.

With joint reference to FIGS. **1**, **4** and **5**, we describe how the access controller coordinates a burst access of a mobile station (e.g., **MS1.1**) during soft handoff from a base station **BS1** in cell **100** and a neighbor base station **BS2** in cell **120**. The steps **409**, **411** and **415** proceed as previously described. FIG. **5** shows a burst acceptance message **501** sent to access controller which performs the processing steps **413** required during the soft handoff. These processing steps will be described in more detail in later paragraphs with reference to FIGS. **6**, **7** and **8**. After processing, access controller sends a data burst assignment command, step **503**, to both base stations and they send the data burst assignment message **415** to the requesting mobile station.

Autonomous Access Control

With reference to FIG. **6**, we describe our autonomous access control feature of the present invention. As described in step **411** above, the mobile station provides pilot strength measurements (e.g., PMRM) in the access request. If the host's load condition is too close to a predetermined load level, step **600**, then a retry delay command is sent, in step **600***a*. If the host load condition permits a burst access, but the mobile is in a soft handoff, step **601**, then the access controller limits the mobile to the basic data rate B (i.e., multiplier m=1). The burst assignment message, step **605**, permitting a data rate of m times the basic rate B is sent to the requesting mobile. If the host load condition permits burst access and the mobile is not in soft handoff, then step **607** is performed. In step **607**, the base station pilot strength measurements for all neighbors, 'i', are determined. The pilot strength measurement P/z_i (PMRM of 411) is formed for all base stations 'i' in the neighbor list, where P is the known transmission power level of the base stations and z_i is the path loss or radio distance. If P/z_i is below a high rate data access threshold T_{hra}, it indicates that the mobile will not cause any excess interference to neighbor base stations and the mobile is permitted (step **609**) to transmit a rate which is the minimum of the requested multiple M or the maximum multiple M_R. (The mobile and the base station can locally generate the M codes needed for the multiple rate transmissions using subcode concatenation in MC-CDMA as described in the previously referenced patent). In step **605**, the access controller sends the burst assignment message to the requesting mobile.

The threshold T_{hra} is chosen such that the total interference received from a requesting mobile at any neighbor base station is less than I_0. Note that to accommodate high rate data users the system may limit the number of voice users N_v

to be smaller than the maximum permissible in a voice-only system. There is a tradeoff between raising T_{hra} and increasing N_v, the number of voice users per cell.

If it is determined that the requesting mobile is to be permitted to transmit at the high rate, the base station may have to schedule the burst transmission. Since the load and interference situation may be time varying, the decision to permit is valid only for a period of time Q that depends on system load, shadow fading dynamics, and user mobility. This time Q corresponds to L frame durations. The base station checks its list of scheduled bursts and adds the requesting mobile to the list if it is shorter than L frames.

If any one of the neighbor base station pilot strengths (P/z_i) in step **607** is determined to be higher than the threshold T_{hra}, the mobile is permitted only to transmit at the basic rate B, step **603**. High rate access will not be allowed for the requesting mobile until all neighbor base station pilot strengths are found to be below T_{hra}. Note that the soft handoff decisions are made separately. The soft handoff add and drop thresholds T_{add} and T_{drop} will typically be larger than the high rate data access threshold T_{hra}. Consequently, as previously discussed in step **601**, mobiles in soft handoff will only be allowed to transmit at the basic rate B (i.e., m=1). Conversely, any transmission at basic rate B requires no demand assignment.

This autonomous access control is attractive for its simplicity, but it has some limitations. For example, mobiles may be in soft handoff in a significant portion of the coverage area. Schemes that permit higher rate access even during soft handoff are presented hereinafter.

Enhanced Autonomous Access Control

With reference to FIG. 7, we describe our enhanced autonomous access control feature. The previously described autonomous access control permits only two selection data rates, namely a basic rate (m=1, step **603**) and a high rate, which is the minimum of the requested rate M or the system's maximum rate M_R (step **609**). The enhanced autonomous access control feature creates multiple thresholds which increase the coverage area for higher rate data users such that rates two, three, . . . times (even non-integer multiples) higher than the basic rate B can be assigned. Thus, data users requesting higher data rates are usually assigned a higher data rate when they are more centrally located in their cell and assigned succeedingly lower data rates as they approach a cell boundary.

In steps **700** and **700a**, the host cell's load condition check is performed in the same manner as in steps **600** and **600a**. If the mobile (e.g., **MS1.1**) is in soft handoff, then step **703** and step **705** are performed in the same manner as steps **603** and **605**. However, if the mobile is not in soft handoff, then the access controller selects a data rate using step **707**. In step **707**, the maximum pilot strength P/z_i from all base stations 'i' in the neighborhood is determined from the set of pilot strength measurements reported by mobile **MS1.1**, in step **411**. The access controller compares the maximum pilot strength with a set of thresholds $\{T_m, m=0, 1, \ldots M_R\}$, where $T_m > T_{m+1}$, as shown in FIG. **10**. Each threshold T_m corresponds to a different permitted data rate multiple m. For consistency, $T_0=P$ and $T_{M_R}=T_{hra}$. If any neighbor's pilot strength P/z_i is not below the threshold T_1, then the mobile **MS1.1** is permitted by its base station **BS1** only to access the basic rate B (m=1), as shown in step **703**. If the maximum of pilot strength P/z_i is between T_m and T_{m-1}, then the data rate multiple m is selected as shown in FIG. **10**, so that the interference at any neighbor cell's base station is less than I_0.

Again, in step **709**, the access controller selects the data rate multiple m to be no greater than the system limit M_R and the requested multiple M. In step **705**, the burst assignment message **503** includes the rate multiple m. As before, the base station checks its list of scheduled bursts and adds the mobile to its request list, if the list is shorter than L frames, and transmits the assignment message **415** to the mobile. If the scheduled list is longer than the threshold L, the mobile is told in message **415** to retry later.

On the other hand, if in step **707** any neighbor's pilot strength is above the T_1 threshold, then it means that a high rate transmission from that mobile **MS1.1** may cause excessive interference in that neighbor's cell. Consequently, the mobile is restricted to the base rate (m=1) as shown in step **703**.

The present invention enables an access controller, either centrally located or located at one or more base stations, e.g., **BS1**, to autonomously determine the largest value of 'm', corresponding to 'm' times the basic rate B, at which the mobile **MS1.1** may transmit while satisfying the following interference constraint:

$$\alpha N_v(1+\gamma^s)\alpha m\gamma_d^s(z_1,z_2)\leqq I_0^s, \tag{5}$$

where $\gamma_d^s(z_1,z_2)=1$ for the host cell. Thresholds $\{T_m\}$ are defined to satisfy Equation 5 for bit rate multiples m=1, 2, . . . ; up to M_R. Again, mobiles in soft handoff will be only allowed to transmit at basic rate (m=1); which requires no extra negotiations among cells involved in the handoff.

This enhanced scheme of FIG. **7** requires little additional complexity as compared to the single threshold scheme of FIG. **6**.

With reference to FIG. **9**, there is shown a graph of how allowed data rates for a mobile user in a cell with 25 voice users vary as a function of the distance to the base station, assuming 21 voice users are in the handoff cell. FIG. **9** shows that these multiple thresholds **901–904** are quite close to each other and may not be distinguishable within the noisy pilot strength measurements; and the drop off from acceptable interference at m times the basic rate B (**902–904**) to basic rate B (**901**) is quite rapid in terms of the normalized distance from the base station.

Neighbor Coordinated Access Control

With reference to FIG. **8**, we describe our neighbor coordinated access control feature. Neither of the schemes above account for instantaneous loading in the neighbor cells. As discussed in the following paragraphs, light loading in neighbor cells can be exploited to permit higher rate access while still meeting the interference constraint I_0^s.

When a mobile **MS1.1** is connected to a single base station **BS1**, the rate assignment decision in response to a high data rate access request, **411**, is facilitated if the load at the neighbor cells is known, **802**, to the base station **BS1**. In step **803**, the base station computes the mean load $\overline{N}_v$. In step **805**, instead of fixed thresholds, the base station **BS1** makes rate assignment decisions by determining the smallest 'm' that satisfies the following inequality for all neighbor base stations and itself:

$$\alpha(N_v^i+\bar{N}_v\gamma^s)+m\gamma_d^s(z_1,z_i)\leqq I_0^s, \tag{6}$$

where $\overline{N}_v$ is the average number of voice users per cell in the neighborhood, N_v^i is the number of voice calls in cell 'i' and z_i is the "radio distance" of the data user to base station of cell 'i', where 'i' is the index of the neighbor list. The host cell corresponds to i=1. Actually, for each neighbor cell, the

value N_v^i should be considered as the "load in terms of equivalent" voice calls. By choosing the smallest 'm' that satisfies Equation 6 (step **805**) for all neighbor cells 'i', we ensure that the admission of a burst at 'm' times the basic rate B will not cause excessive interference at any neighbor. In this case, the only communication required is for the neighbor cells to periodically provide updates, step **802**, of their current load. In step **807**, the multiple 'm' is selected to be the minimum of m_i, M and M_R. In step **809**, if the mobile is not in soft handoff, then, as before, if the scheduled list is shorter than L frames, the rate assignment and burst parameters are provided to the mobile, step **811**; otherwise, the mobile is told in step **811** to retry.

When the mobile is in soft handoff, in step **809**, the access request (that includes pilot strength measurements) is received by all the connected base stations. Again, the simplest strategy is to let the mobile transmit only at the basic rate (without access control) when it is in soft handoff. To permit higher data rates in soft handoff, more sophisticated coordination between neighbor base stations is necessary. Each base station performs similar computations as in step **805** to determine the maximum permitted rate 'm', the permitted burst length and the earliest starting time. However, instead of transmitting this assignment to the mobile, this information is forwarded, in step **813**, to the access controller located at the "primary" base station or at the central switch (**190** of FIG. **1**). The controller **190** compares the assignment made by each of the base stations, and then chooses the minimum of the rate assignments and burst lengths proposed by the soft handoff cells and the last of the proposed starting times. It then creates the assignment message (**503** of FIG. **5**) and transmits it to the mobile in soft handoff (step **415** of FIG. **5**). If any one of the base stations indicates that its scheduled list is long and the mobile must retry, then a retry message is sent out to the mobile in step **415**. Note that because the controller **190** must choose the minimum of the rates allowed by the different cells and the last of the starting times, care must be taken to avoid compromising channel utilization efficiency in the cells involved in the soft handoff.

When the present invention is implemented as a MC-CDMA system with LIDA, it offers the following features:

- It provides data services at high access bandwidths with minimal changes to the IS-**95** air interface and the IS-**99** data standard (up to 56 kbps for IS-**99**-based CDMA and related standards).
- It is well suited for use with sub-code concatenation, as described in the previously referenced patent.
- The high bandwidth demand assignment per burst is based on load and channel conditions.
- Access control in the network ensures priority for voice and other high priority users.
- It uses transmitter oriented codes with dedicated receivers per connection.
- It sacrifices (some) Forward Error Correction (FEC) in favor of retransmission using ARQ to reduce E_b/N_0 requirement, and increase capacity.

Although our control scheme provides high rate access using MC-CDMA, the control scheme, LIDA, presented is transparent and thus equally applicable to any physical layer implementation of higher data rate access over CDMA.

What has been described is merely illustrative of the application of the principles of the present invention. Other arrangements and methods can be implemented by those skilled in the art without departing from the spirit and scope of the present invention.

We claim:

1. In a code division multiple access system including multiple cells, each cell having a base station and multiple mobile stations, a method of allocating bandwidth to a mobile station comprising the steps of:

receiving, at a base station of a first cell, a data burst request from an active mobile station of said first cell requesting a first data rate in excess of the basic data rate (B) allocated to that mobile station, said data burst request including pilot strength information for the base station of said first cell and a base station of at least one cell adjacent to said first cell;

at an access controller, using the received pilot strength information to determine an increased data rate which is to be granted to said requesting mobile station without causing excessive interference at said first cell and said at least one adjacent cell; and

transmitting a data burst assignment response from the access controller to said requesting mobile station indicating the increased data rate which has been granted to said requesting mobile station.

2. The method of claim **1** wherein

the access controller compares the received pilot strength information with a threshold and wherein the increased data rate is assigned to said requesting mobile station when the received pilot strengths have a predetermined relationship to that threshold.

3. The method of claim **2** wherein

the pilot strength information is provided for base stations at a plurality of cells adjacent said first cell and wherein

the first data rate is granted when the received pilot strength from any of the base stations at the plurality of adjacent cells, as reported by said requesting mobile station, does not exceed the threshold.

4. The method of claim **2** wherein the threshold is a high rate access threshold (T_{hra}) that is lower than soft handoff add (T_{add}) and drop (T_{drop}) thresholds.

5. The method of claim **2** wherein the threshold is a high rate access threshold (T_{hra}) that has a predetermined relationship with add (T_{add}) and drop (T_{drop}) thresholds.

6. The method of claim **2** further including the step of:

transmitting a data burst assignment response to said requesting mobile station when any received pilot strength information is above the threshold, the data burst assignment response enabling a data transmission rate at the requesting mobile station which is lower than a data rate permitted when the received pilot strength information is below the threshold.

7. The method of claim **2** wherein the data burst assignment response indicates that the first data rate is denied when the pilot strength information is above the threshold.

8. The method of claim **1** wherein

the burst request includes data burst length information and wherein

the data burst assignment response includes a data burst length parameter specifying a permitted length of a data burst to the requesting mobile station.

9. The method of claim **4** wherein said base station includes the step of

determining if the requested burst length information is to be permitted and, when permitted, including a permitted-data-burst-length parameter in the data burst assignment response.

10. The method of claim **1** wherein the data burst assignment response includes retry delay information indicating that the requesting mobile station should retry its request at a later time.

11. The method of claim 1 wherein the data burst assignment response includes start-delay information indicating that the requesting mobile station should delay its transmission for a time derived from the start-delay information.

12. The method of claim 1 further including the steps of

checking a list of scheduled data bursts at the base station and wherein the data burst assignment response includes

a retry later message when the list is longer than a predetermined length and

a data burst permission message when the list is shorter than the predetermined length.

13. The method of claim 1 wherein the access controller is located at one or more base stations including the first cell.

14. The method of claim 1 wherein the access controller is located apart from any base station.

15. The method of claim 1 wherein a set of thresholds are associated with multiple data burst rates, and wherein the access controller compares received pilot strengths from said at least one adjacent cell with the set of thresholds to determine a data rate to be granted to said requesting mobile station.

16. The method of claim 15 wherein the set of thresholds, each having a data burst rate associated therewith, and wherein the access controller compares the maximum of the received pilot strengths from said at least one adjacent cell with the set of thresholds to determine a data rate to be granted to the requesting mobile station.

17. The method of claim 1 further comprising the steps of:

receiving, at the access controller, a neighbor load update message indicating load measure information at said at least one adjacent cell;

at the access controller, using the received pilot strength and load measure information to determine an increased data rate which can be granted to said requesting mobile station without causing excessive interference at said first cell and said at least one adjacent cell; and

transmitting a data burst assignment response from the access controller to said requesting mobile station indicating the increased data rate which has been granted to said requesting mobile station.

18. The method of claim 17 further comprising the steps of:

at the access controller, computing the smallest 'm' that satisfies the following inequality for all neighbor base stations, 'i', $\alpha(N_v^i+\overline{N}_v\gamma^s)+m\gamma_d^s(z_1,z_i)\leqq I_0^s$, where $\overline{N}_v$ is the average load in equivalent voice users per cell in the neighborhood, N_v^i is the load in equivalent voice calls in cell 'i', and z_i is the radio distance of the data user to cell 'i', which is derived from the pilot measurement, and where $\gamma_d^s(z_1,z_i)=z_i/z_1$; and

transmitting a data burst assignment response from the access controller to said requesting mobile station indicating a data rate mB has been granted to the requesting mobile station.

19. The method of claim 17 wherein when a mobile station is communicating with more than one base stations at multiple cells,

at an access controller, using the received pilot strength and the load measure information from each of the more than one base stations to determine an increased data rate which can be granted to said requesting mobile station without causing excessive interference at the multiple cells and at any cell adjacent to those multiple cells; and

transmitting a data burst assignment response from the access controller to said requesting mobile station indicating the increased data rate which has been granted to said requesting mobile station.

20. The method of claim 19 wherein the access controller determines an increased data rate permitted for each base station and selects the minimum data rate therefrom and transmits the selected minimum data rate to said requesting mobile station.

21. A code division multiple access system including multiple cells, each cell having a base station and multiple mobile stations, the system comprising:

receiving means, at a base station of a first cell, receiving a data burst request from an active mobile station of said first cell requesting a first data rate in excess of the basic data rate (B) allocated to that mobile station, said data burst request including pilot strength information for the base station of said first cell and a base station of at least one cell adjacent to said first cell; and

an access controller, using the received pilot strength information to determine an increased data rate which is to be granted to said requesting mobile station without causing excessive interference at said first cell and said at least one adjacent cell and transmitting a data burst assignment response to said requesting mobile station indicating the increased data rate which has been granted to said requesting mobile station.

22. The code division multiple access system of claim 21 wherein

the access controller compares the received pilot strength information with a threshold and wherein the increased data rate is assigned to said requesting mobile station when the received pilot strengths have a predetermined relationship to that threshold.

23. The code division multiple access system of claim 21 wherein a set of thresholds are associated with multiple data burst rates, and wherein the access controller compares received pilot strengths from said at least one adjacent cell with the set of thresholds to determine a data rate to be granted to said requesting mobile station.

24. The code division multiple access system of claim 21 wherein:

the access controller receives a neighbor load update message indicating load measure information at said at least one adjacent cell, uses the received pilot strength and load measure information to determine an increased data rate which can be granted to said requesting mobile station without causing excessive interference at said first cell and said at least one adjacent cell, and transmits a data burst assignment response to said requesting mobile station indicating the increased data rate which has been granted to said requesting mobile station.

25. The code division multiple access system of claim 21 wherein: the access controller computes the smallest 'm' that satisfies the following inequality for all neighbor base stations, 'i', $\alpha(N_v^i+\overline{N}_v\gamma^s)+m\gamma_d^s(z_1,z_i)\leqq I_0^s$, where $\overline{N}_v$ is the average load in equivalent voice users per cell in the neighborhood, N_v^i is the load in equivalent voice calls in cell 'i', and z_i is the radio distance of the data user to cell 'i', which is derived from the pilot measurement, and where $\gamma_d^s(z_1,z_i)=z_i/z_1$; and transmits a data burst assignment response from the access controller to said requesting mobile station indicating a data rate mB has been granted to the requesting mobile station.

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